

VECTOR WIND GUST MODEL

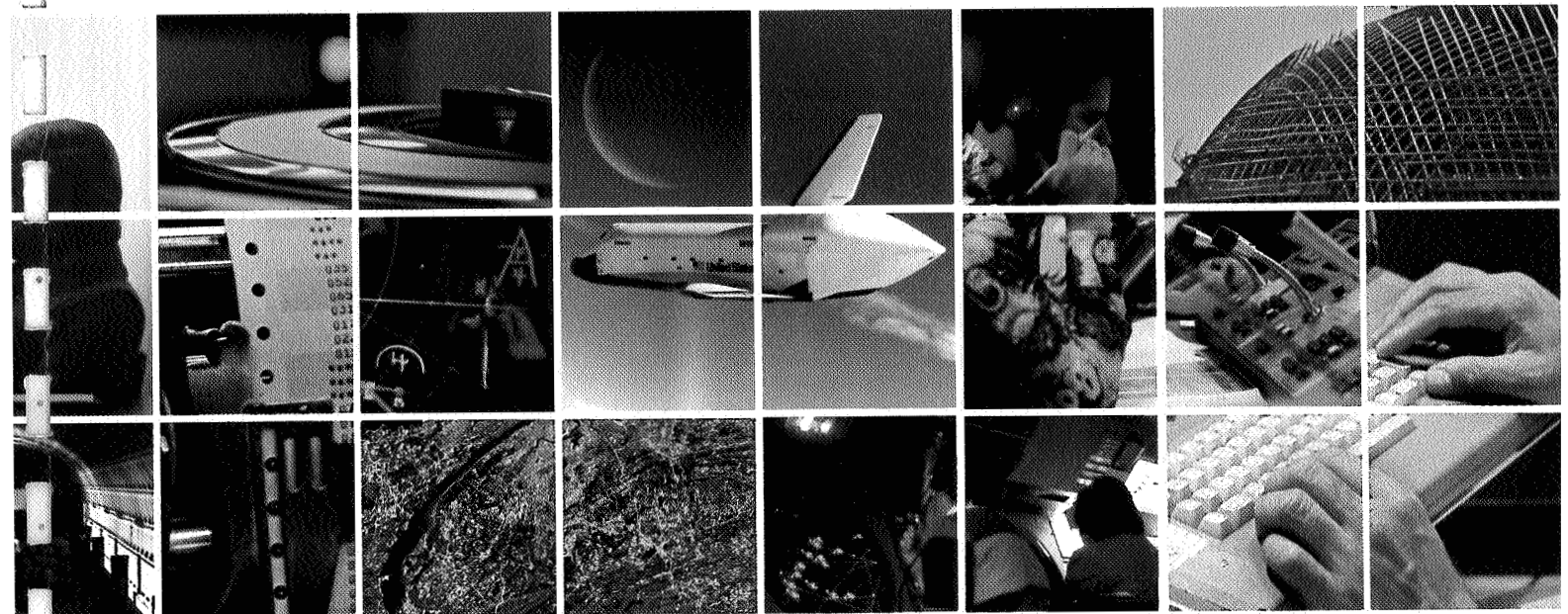
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FINAL REPORT

(For the Period February 14, 1979 - April 13, 1984)

Contract NAS8-33433

April 13, 1984



CSC
COMPUTER SCIENCES CORPORATION
APPLIED TECHNOLOGY DIVISION

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Prepared By

Stanley I. Adelfang
Computer Sciences Corporation
555 Sparkman Drive, Suite 1200
Huntsville, AL 35805

Prepared For

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

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I. INTRODUCTION

The purpose of this report is to summarize studies performed under contract **NAS8-33433** during the period April 14, 1979, through April 13, 1984. These studies have been described in monthly and annual reports, in national meeting proceedings, and in the open literature. If the previously published work has not been revised, it will be abstracted in Section II of this report. Revised or expanded work or work that has not yet been published will be included in Section III. Conclusions and recommendations are given in Section IV.

II. SUMMARY OF PUBLISHED WORK

Abstracts of annual reports, papers published in conference proceedings, and papers published in the open literature are presented in chronological order below.

Adelfang, S.I., and Evans, B.A. (1980), "Vector Wind Profile Gust Model," Annual Report for Period 4/79 through 4/80. NASA CR-161475, Marshall Space Flight Center, Alabama.

A statistical model based on the γ distribution is proposed for wind perturbations observed in detailed vertical wind profiles. Model parameters are estimated from Jimsphere wind profile data. Digital filtering is used for extraction of wind perturbation data in selected wavelength bands. The probability distribution of wind perturbations in four wavelength bands is derived. The analytical techniques established in this study are applicable to Space Shuttle launch analyses.

Adelfang, S.I., and Smith, O.E. (1981), "Vector Wind Profile Gust Model," Annual Report for Period 4/80 through 4/81. NASA TM-82441, Marshall Space Flight Center, Alabama.

The further development of a vector wind gust model suitable for Space Shuttle launch analysis is described. Emphasis is given to verification of the hypothesis that gust component variables are γ distributed, gust modulus is approximately Weibull distributed, and zonal and meridional gust components are bivariate γ distributed. A method of testing for bivariate γ distributed variables is described, two distributions for gust modulus are proposed, the results of extensive hypothesis testing of one of the distributions are presented, and the validity of the γ distribution for representation of gust component variables is established.

Smith, O.E., and Adelfang, S.I. (1981), "Gust Model Based on the Bivariate γ Probability Distribution," Jour. Spacecraft and Rockets, Vol. 18, No. 6, Nov-Dec 1981, p. 545. Paper also presented at the AIAA 19th Aerospace Sciences Meeting, St. Louis, January 1981.

The conventional approach to gust modeling for vertically rising vehicles involves the application of a digital filter to a sample of Jimsphere wind profiles, defining the resulting residual amplitudes as gusts,

and developing statistical summaries or power spectra of the gusts. In this paper a new approach models the largest gust amplitude and gust length using the properties of the bivariate gamma distribution. The gust amplitude and gust length are strongly dependent on the filter function. Gust amplitude increases with altitude and is larger in winter than in summer.

Smith, O.E., Adelfang, S.I., and Tubbs, J.D. (1982), "A Bivariate Gamma Probability Distribution with Application to Gust Modeling," NASA TM-82483, Marshall Space Flight Center, Alabama. Elements of this report were included in a paper presented at the American Statistical Association National Annual Meeting, August 16-19, 1982, at Cincinnati, Ohio. This paper is being reviewed for publication in Communications in Statistics.

A five-parameter bivariate gamma distribution (BGD) having two shape parameters, two scale parameters, and a correlation parameter has been derived. This general BGD is expressed as a double series and as a single series of the modified Bessel function. This general BGD reduces to the known special case for equal shape parameters. The conditional distributions are of special interest. An approximating distribution for the modulus of two orthogonal independent gamma distributed variates has been derived. Practical functions for computer evaluations for the general BGD and for many special cases are presented. Problems in parameter estimation and hypotheses testing are discussed. Applications of the general BGD are to be found in reliability theory, signal noise, and meteorology. In this paper, applications to wind gust modeling for the ascent flight of the Space Shuttle are illustrated.

Adelfang, S.I., and Smith, O.E. (1983), "Information Retrieval from Wide Band Meteorological Data, An Example," Proceedings of the Ninth Conference on Aerospace and Aeronautical Meteorology, June 6-9, 1983, Omaha, Nebraska. American Meteorological Society, Boston, Massachusetts.

New concepts for analysis of wind perturbations in vertical wind profiles are applied to a sample of detailed wind profiles. Digital filters are used to extract sets of band-pass filtered profiles with essentially non-overlapping wavelengths. Probabilities are calculated over different geometric regions within the domain of bivariate gamma distributed variables; probabilities over the same regions are also calculated from

the observed distributions and a comparison is presented to illustrate the accuracy of the statistical model. These and other statistical results are calculated from samples of Jimsphere wind profiles at Cape Canaveral, Florida, for various wavelength bands, altitudes, and seasons.

III. NEW OR REVISED STUDIES

A. Wind Perturbation Statistics

Design and performance analyses of launch vehicles requires realistic assessment of wind profile perturbations. To satisfy this requirement, statistics of wind perturbations have been calculated for two Space Shuttle launch sites: Cape Kennedy, Florida (KSC), and Vandenberg Air Force Base, California (VAFB).

Data

Three data bases are available for analysis: two from VAFB and one from KSC. At KSC, during the 1960's, there was an intensive Jimsphere wind profile measurement program in connection with the Saturn/Apollo program and other NASA research and development efforts (Vaughan, 1968). A data set for design and simulation studies consisting of 150 profiles per month was selected from the large Jimsphere data base at KSC (Brown, 1978). The profiles were subjected to quality control procedures and data editing was used when obvious data errors were found: this data base is referred to as the KSC design sample.

At VAFB, the number and quality of Jimsphere profiles was not up to the KSC standard so that it was necessary at first to create detailed profiles by supplementing available rawinsonde data with perturbations generated by a turbulence model developed by Fichtl and Perlmutter (1976). This data base, also consisting of 150 profiles per month, is known as the VAFB design sample. Recently, as more VAFB Jimsphere profiles became available, another data base was assembled consisting of 150 edited profiles for each of three seasonal periods: winter, summer, and transition. This data base is referred to as the VAFB Jimsphere seasonal data.

All the wind profiles utilized were band-pass filtered to obtain perturbations in the 420-2470m wavelength band. This wavelength band, in combination with the wide range of launch vehicle velocities, translates into a temporal frequency range that includes vehicle control system response modes and coincident structural loading. A general description of the digital filtering technique is given by Demandel and Krivo (1971). To obtain band-pass filtered profiles in the 420-2470m wavelength range, it was necessary to execute two low-pass filters. A schematic of the filtering process is

illustrated in Figure 1. The filter weights are listed in Table 1.

Statistics

The purpose of the statistical analysis is to determine if significant differences exist in the magnitude of wind perturbations at KSC and VAFB. Since two data bases exist for VAFB, it is necessary to establish a basis for choosing one for future engineering application. Since the VAFB seasonal data is based on Jimsphere data, it is preferred at the outset with one reservation: At the present time there is insufficient Jimsphere data to assemble a monthly design sample. If the seasonal data is shown to represent the expected variability, monthly data will not be required for engineering applications.

The u and v component absolute perturbations in the 420 to 2470m wavelength band at 12 km for the various data bases are illustrated in Figures 2 through 6. There is a clear indication that the largest perturbations are observed in Jimsphere wind profiles during the winter and transition periods (KSC design, February and April; VAFB, winter and transition).

As illustrated in Figures 7 and 8, wind perturbation percentiles based on Jimsphere profiles at VAFB are larger in winter and smaller in summer than percentiles based on simulated detailed wind profiles (VAFB design). Thus the variation between winter and summer percentiles is much larger for distributions based on Jimsphere wind profiles. The choice of VAFB data (either simulated or Jimsphere) leads to different conclusions when comparison with KSC data is attempted. VAFB winter percentiles are much larger than KSC February design percentiles; the reverse is true if VAFB January or VAFB February design data are used. VAFB summer v component percentiles agree quite well with KSC July design percentiles; VAFB summer u component percentiles are consistently larger than KSC July design percentiles. If VAFB July design data are used, the percentiles are consistently larger for both components in comparison with KSC July design percentiles.

As illustrated in Figures 9 and 10, the choice of VAFB data for the transition period between winter and summer also affects the comparison with KSC. Distributions based on several transition months were calculated from VAFB design data. The u component distributions are in good agreement with KSC design distributions for April. In contrast, the u component distribution based on VAFB Jimsphere data during

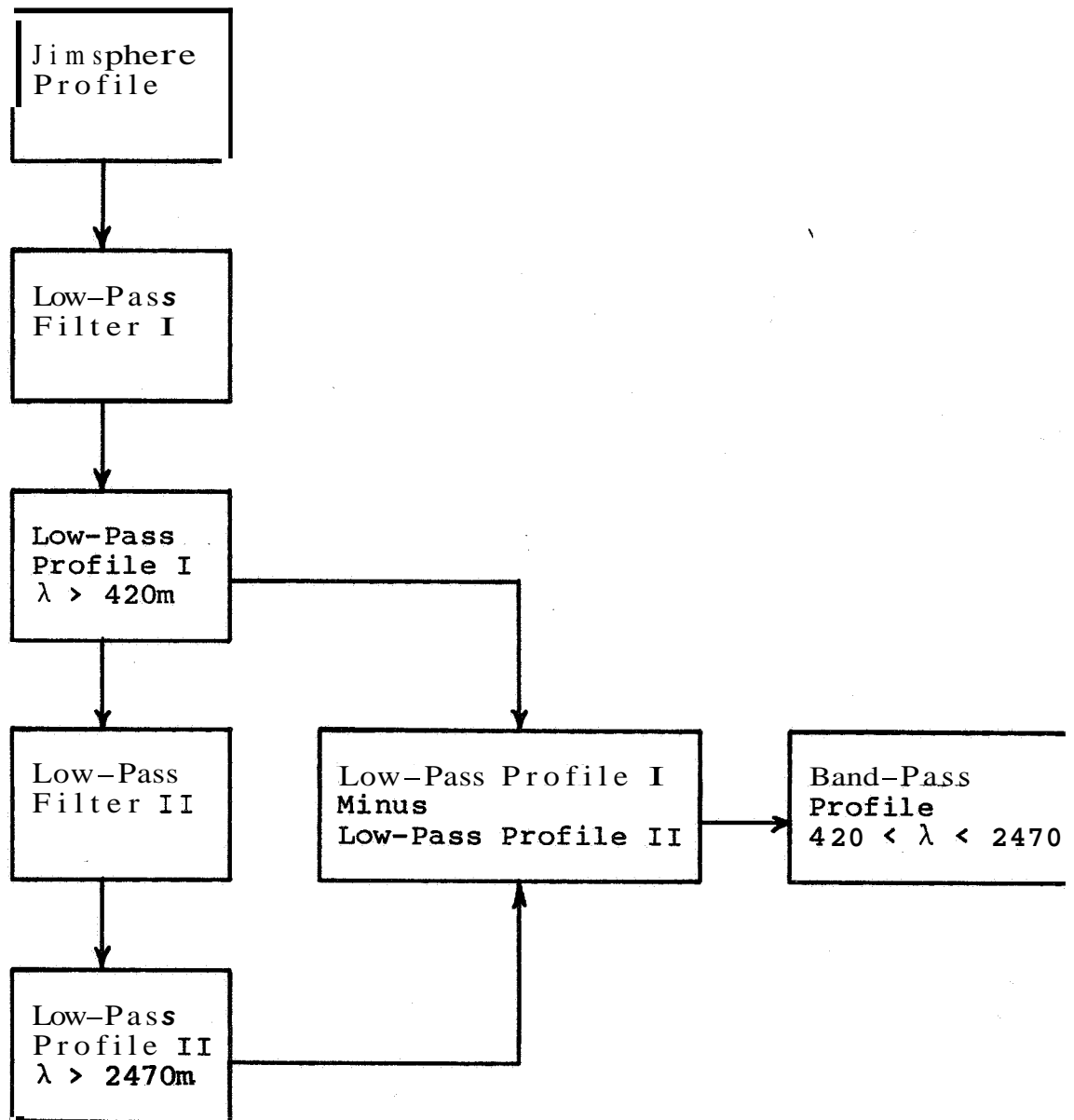


Figure 1. Schematic of Filtering Process

Table 1. Filter Weights, h_i , for Low-Pass Filters I and II

Filter I			Filter II		
Altitude	h_i	Filter Weight	Altitude	h_i	Filter Weight
$z_0^{(1)}$	h_0	.116360050	$z_0^{(2)}$	h_0	0203331671
$z_0 + 25m$	$h_{+1,-1}$	.112681533	$z_0 + 250m$	$h_{+1,-1}$	.182602840
$z_0 + 50m$	$h_{+2,-2}$	.102183235	$z_0 + 500m$	$h_{+2,-2}$	.130080937
$z_0 +$.	.086369542	$z_0 +$	.	.068650095
$z_0 +$.	-.067415386	$z_0 +$	.	0020649325
$z_0 +$.	.047750214	$z_0 + 1250m$	$h_{+5,-5}$	-.003649032
$z_0 +$.	.029618173			
$z_0 +$.	.014711243			
$z_0 +$.	.003949048			
$z_0 +$.	-.002560992			
$z_0 +$.	-.005394941			
$z_0 +$.	-.005565475			
$z_0 +$.	-.004229394			
$z_0 +$.	-.002423366			
$z_0 +$.	-.000884042			
$z_0 +$.	.000021198			
$z_0 +$.	.000259004			
$z_0 +$.	.000022211			
$z_0 +$.	-.000405784			
$z_0 +$.	-.000771288			
$z_0 + 500m$	$h_{+20,-20}$	-.000925530			

(1) $z_0 = 500, 525 \dots 19,500m$

(2) $z_0 = 1750, 1775 \dots 18,250m$

transition indicates larger perturbations at the extreme percentiles. The v component distributions based on VAFB design data indicate smaller perturbations in comparison with KSC design data: there is better agreement between VAFB transition and KSC design.

In conclusion, the probability distribution of wind perturbations at VAFB is strongly dependent on the choice of data base; the choice also affects the results of comparison with KSC. The largest perturbations are found in the VAFB Jimsphere winter data. These perturbations are larger than those found in the KSC design Jimsphere data base. They are also significantly larger than perturbations in the VAFB design data base. It is recommended that for future engineering applications, the VAFB design data base be revised by substitution of VAFB seasonal data to include these large perturbations.

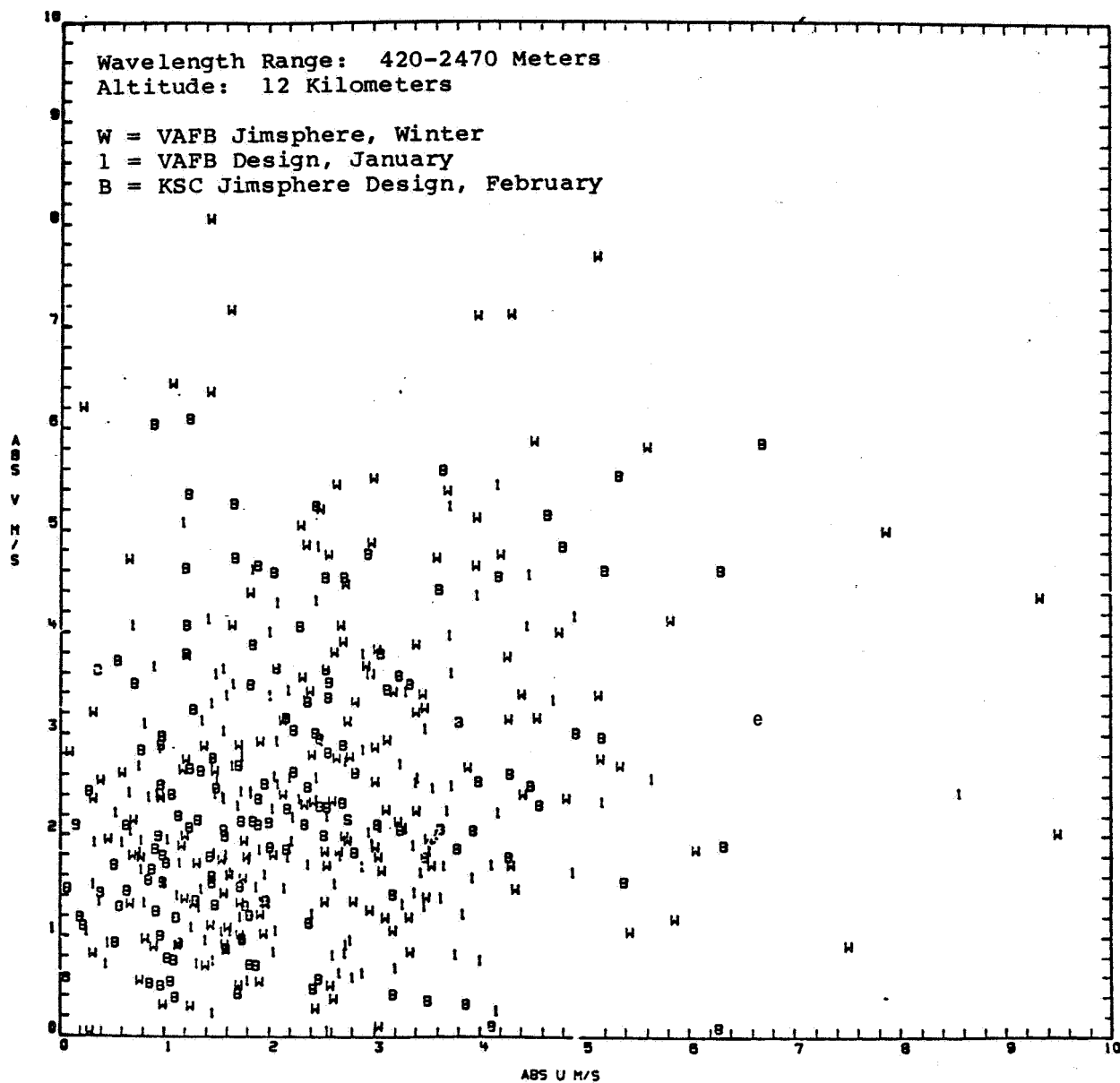


Figure 2. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Winter, VAFB Design January, KSC Design February)

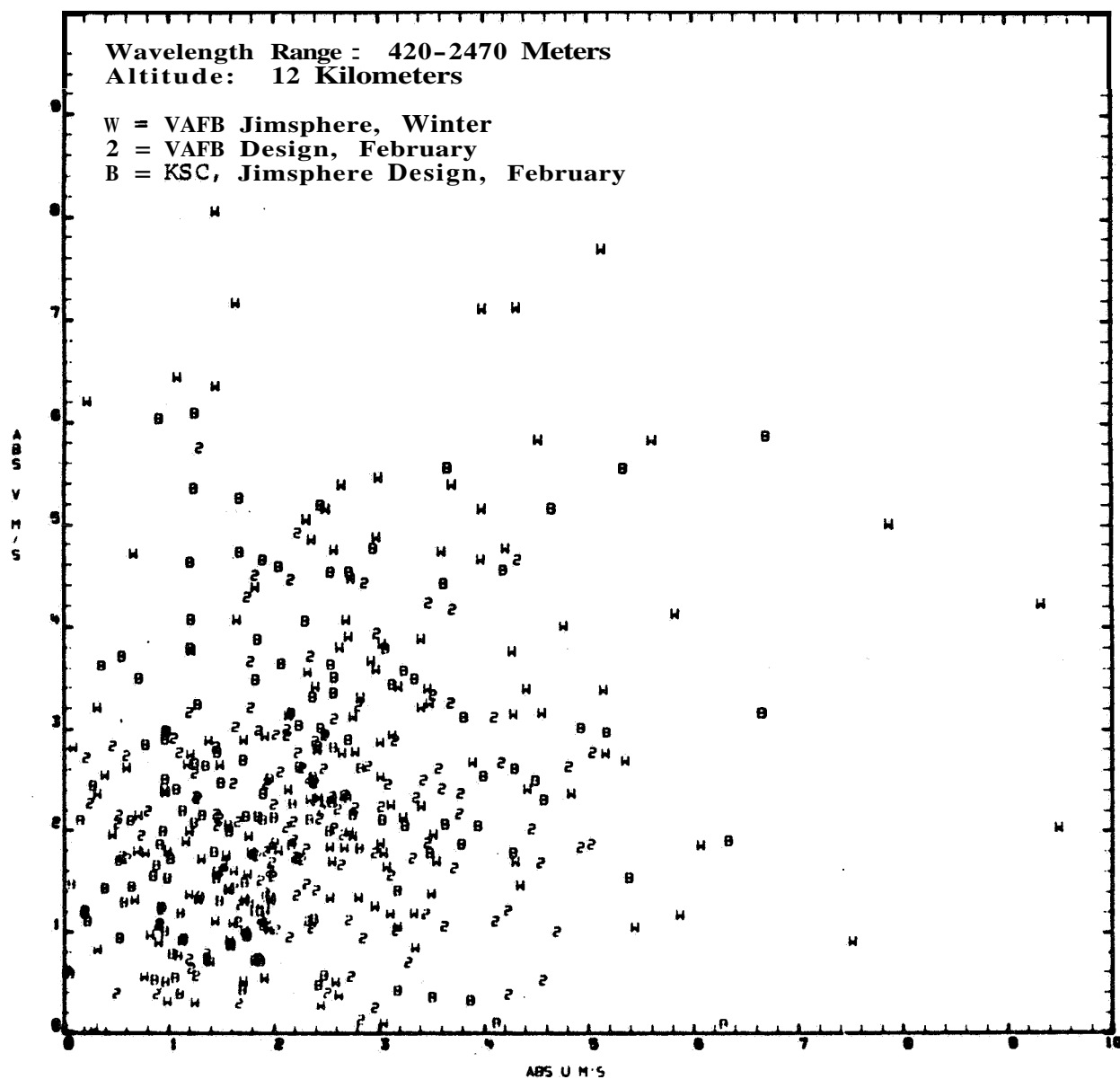


Figure 3. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Winter, VAFB Design February, KSC Design February)

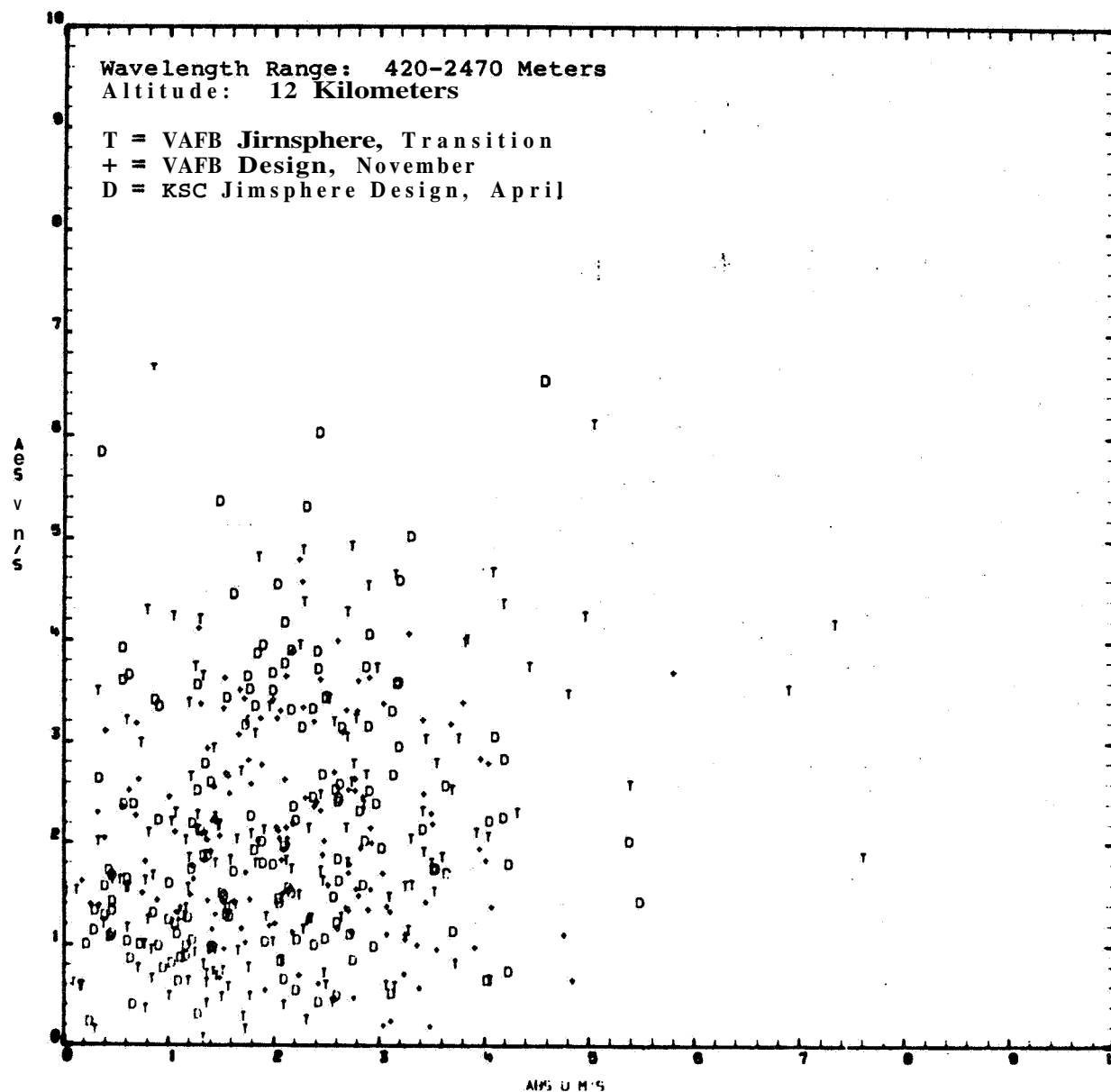


Figure 4. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Transition, VAFB Design November, KSC Design April)

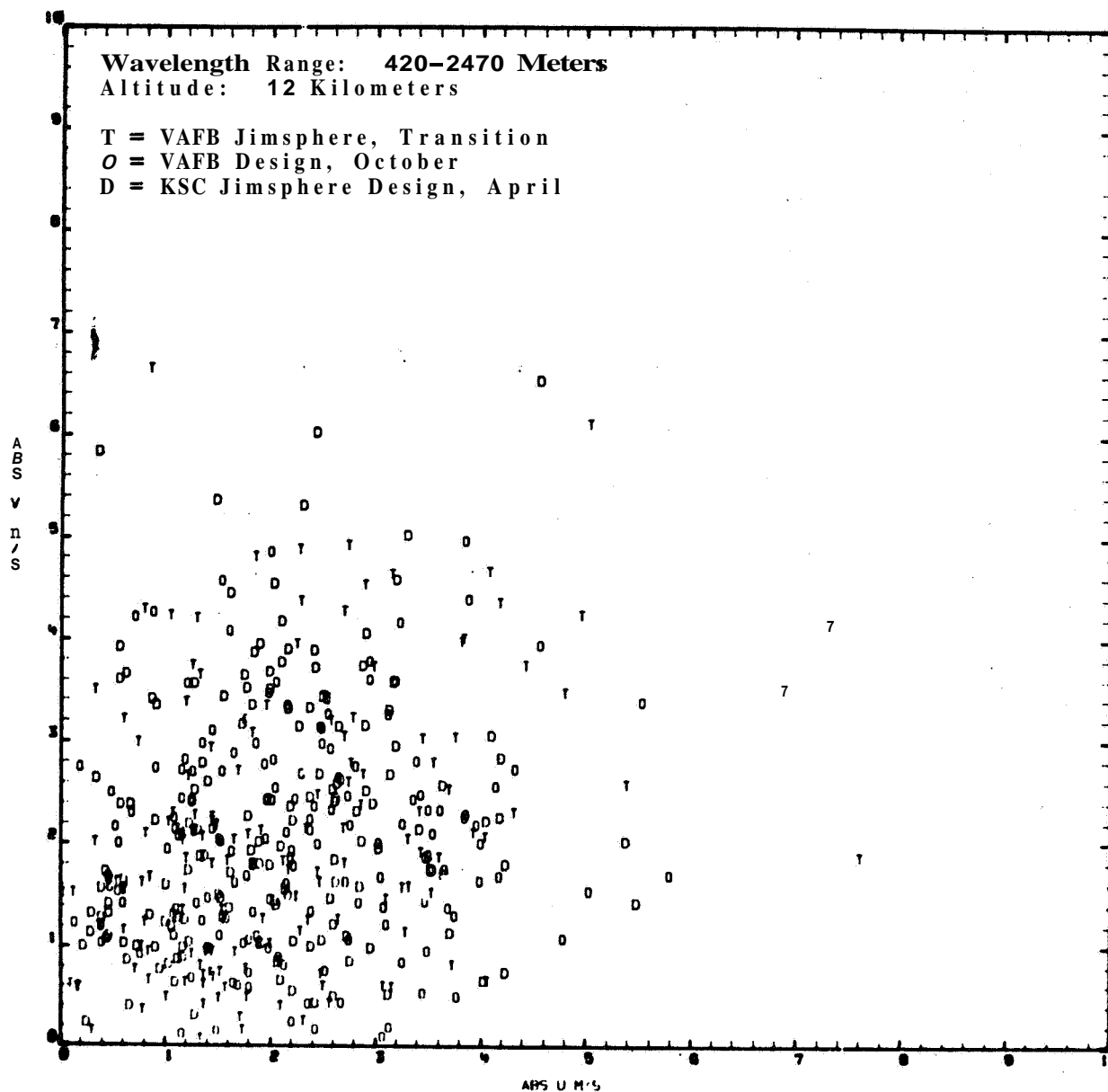


Figure 5. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Transition, VAFB Design October, KSC Design April)

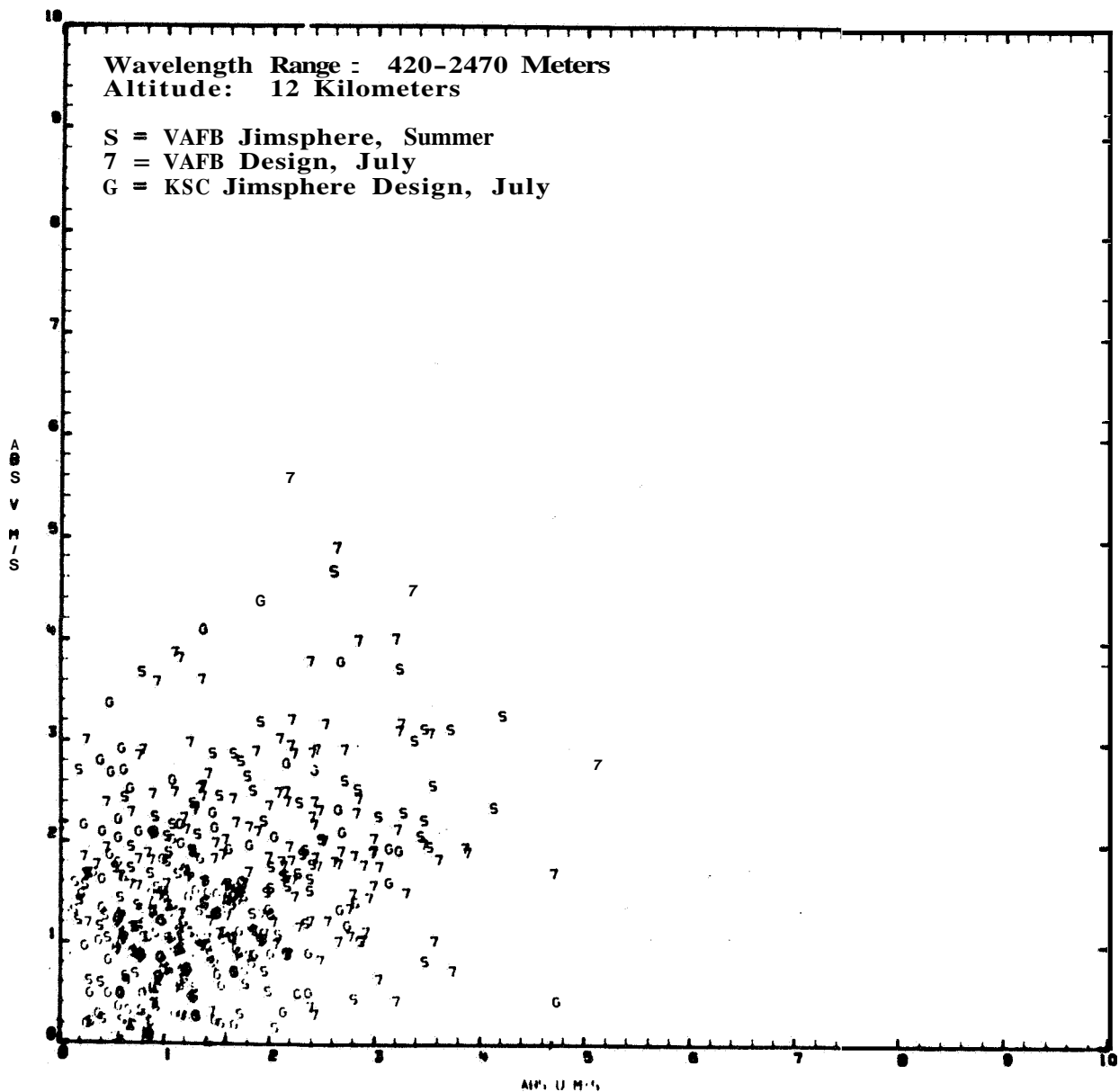


Figure 6. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Summer, VAFB Design July, KSC Design July)

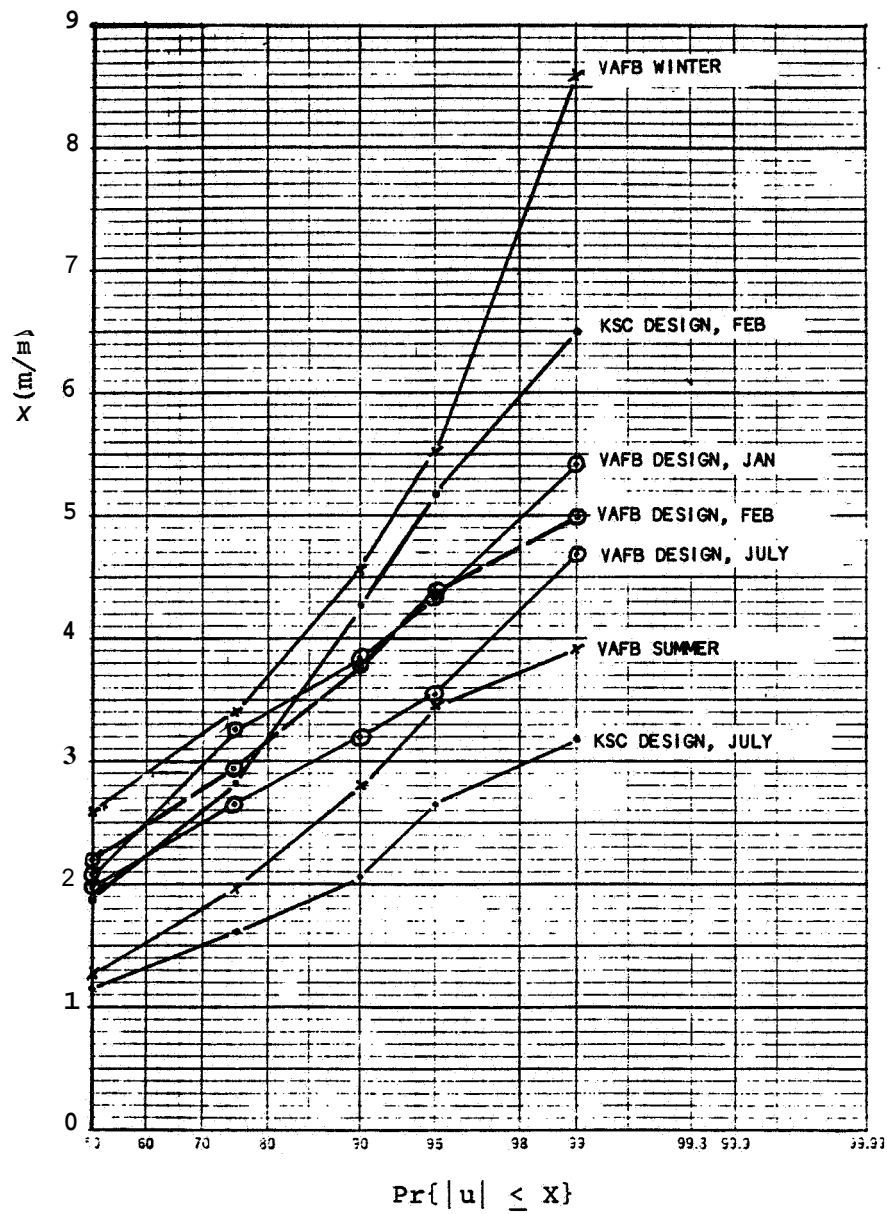


Figure 7. Probability Distribution of Absolute-u Component Perturbation in the 420-2470 Wavelength Band at 12 km During Summer and Winter

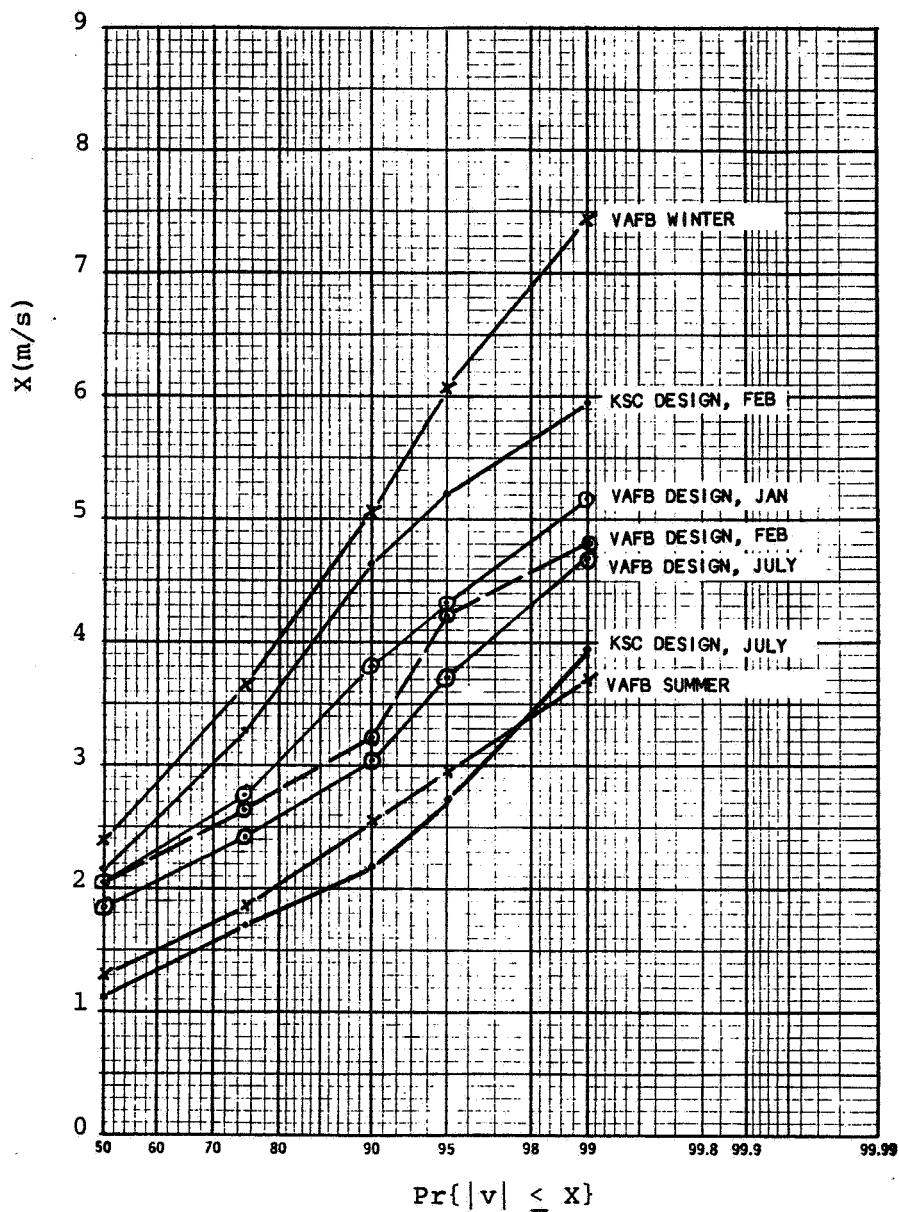


Figure 8. Probability Distribution of Absolute-v Component Perturbation in the 420-2470 Wavelength Band at 12 km During Summer and Winter

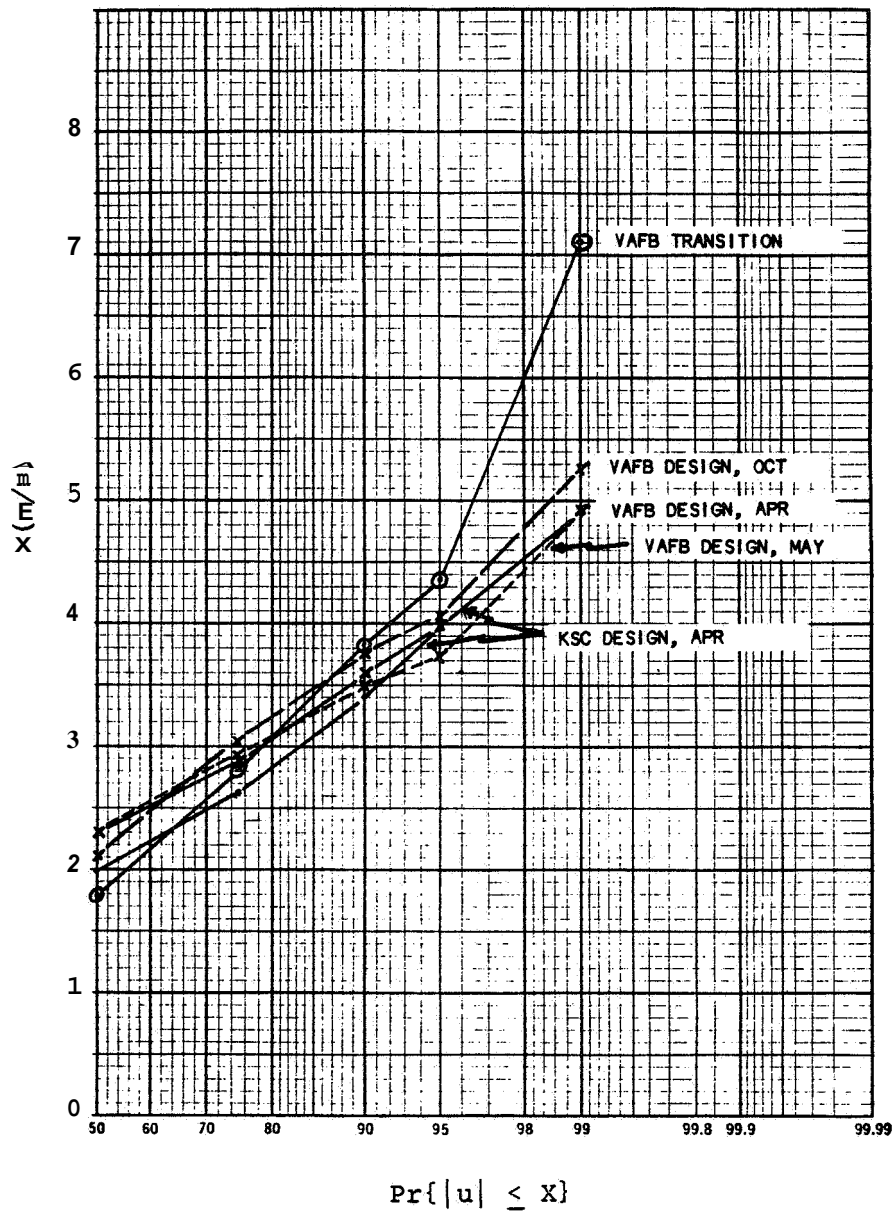


Figure 9. Probability Distribution of Absolute-u Component Perturbation in the 420-2470 Wavelength Band at 12 km During Transition Season

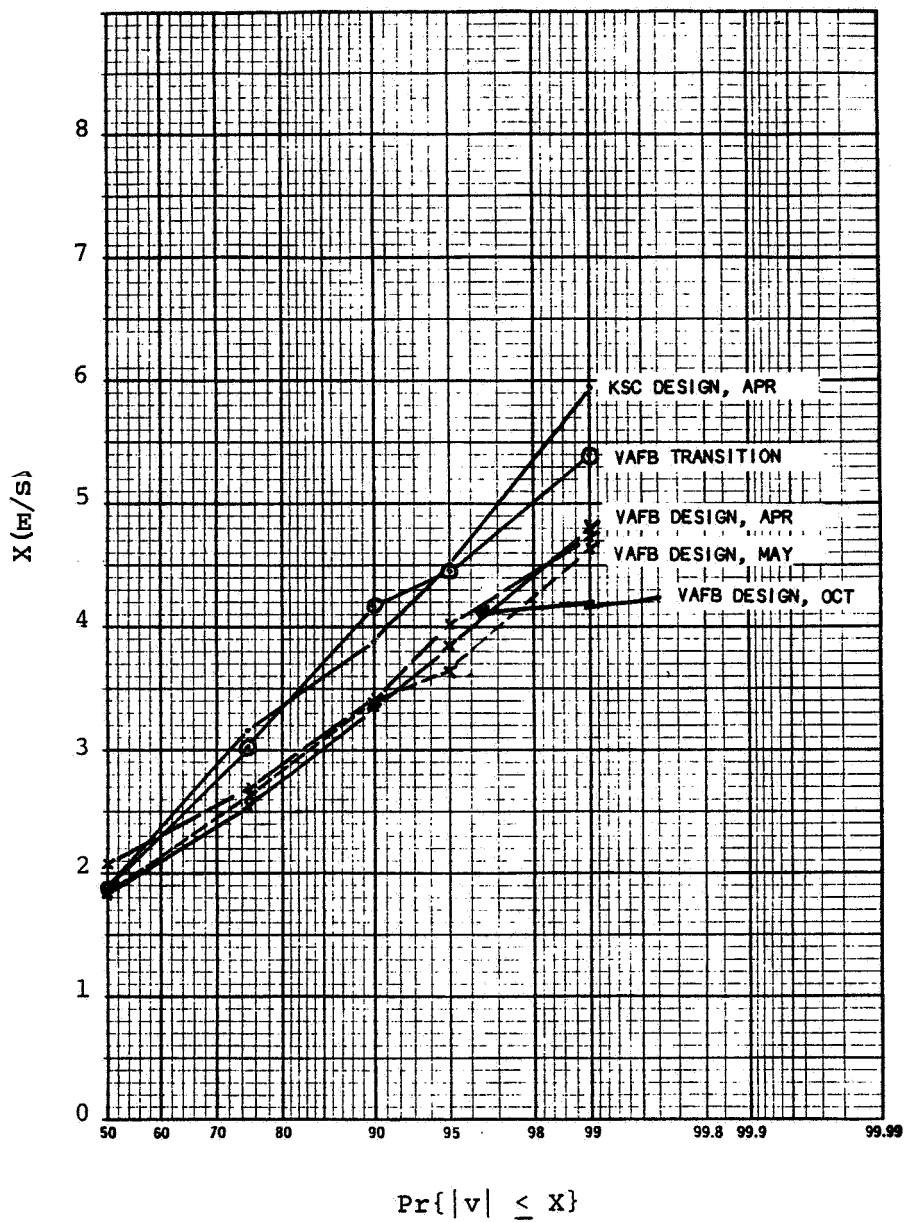


Figure 10. Probability Distribution of Absolute-v Component Perturbation in the 420-2470 Wavelength Band at 12 km During Transition Season

B. Discrete Gust Criteria

The new data described in Section III.A and in previous reports abstracted in Section II can be the basis for revision of existing discrete gust criteria guidelines for use in aerospace vehicle development (NASA TM 78118). To enhance utilization, the guidelines were established by treating gusts in two idealized forms: a quasi-square wave (QSW) non-repetitive form and an approximate sinusoidal form. The QSW form is associated with a length range of 60 to 300m; this is equivalent to a wavelength range of 120 to 600m for a periodic perturbation. It is appropriate to use the later wavelength range for comparison with other data. The QSW form has an amplitude that is independent of wavelength and varies from 6 to 9 m/s depending on altitude. At altitudes above 1 km, the amplitude is a constant, 9 m/s. Peak-to-peak amplitudes associated with the sinusoidal form are considered at best to be preliminary, but are included in this discussion for comparison with the QSW form and results of this study. The principal deficiency of the two forms is the lack of supporting statistical data that justify selection of the gust magnitudes. The results of this study will contribute to alleviation of this deficiency. In addition, there is an indication that future discrete gust criteria can include launch site and seasonal variability, if required.

Discrete gust amplitudes obtained from existing criteria and this study are summarized in Table 2. The 99 percentile values listed under IV were calculated from perturbation distributions at 12 km. Other distributions at 4, 6, 8, 10, and 14 km indicated smaller perturbation (Smith et al., 1982). The large perturbations in the vicinity of 12 km are associated with large wind shear and flow disturbances in the vicinity of the jet stream. Estimates of the 99 percentile discrete gust amplitude at KSC and VAFB (IV) vary by a factor of two for summer and winter and a factor of four for the two wavelength bands (90-420, 420-2470). The winter values for IV are in fair agreement with the sinusoidal gust model (II) and the conditional gamma distribution estimates (III). The 99 percentile of the observed distribution of the largest perturbation amplitude in the 2-15 km altitude range (V) is in most cases somewhat larger than the estimate of the 99 percentile amplitude at 12 km (IV). It should be pointed out that A_{99} is estimated in IV according to the assumptions that A_{99} occurs concurrently with $|u'|_{99}$ and $|v'|_{99}$ and that $|v'|_{99}$ is equivalent to $|u'|_{99}$; these assumptions lead to overestimation of A_{99} . The 9 m/s amplitude of the QSW gust (I) seems to be too large for wavelengths between 120 and 600 meters. If we assume that the QSW gust represents an extreme value beyond the 99 percentile, it is not supported by Jimsphere data at either KSC or VAFB.

Table 2 Description of Gust Models, 4, for Launch Vehicle Design Criteria

λ (m)	Δ (m/sec)									
	JLL					KSC				
	KSC		VAFB (Jimsphere)			FEB		JULY		
	I	II	WINTER	WINTER	WINTER	IV	V	IV	V	Summer
120	9.0	2.7	2.0	3.2						
420	9.0	4.4	3.0	4.8						
90-420						2.2	3.0	1.2	2.3	2.5 4.2 1.8 3.4
420-2470						9.2	8.2	4.5	6.2	12.1 9.6 5.5 7.4
600	3.0	8.1	9.7	11.3						
2470		13.1	13.6	15.6						

I. Quasi-square wave (QSW) embedded jet model, no percentile given, tabular values for altitude > 1 km, NASA TM-78118

II. Sinusoidal gust model, > 99 percentile, 2-15 km, NASA TM-78118

III. Conditional gamma (Smith et al., 1982), parameters calculated from band pass (90-420 m, 420-2470 m) filtered Jimsphere profiles, 99 percentile of "A" estimated at 12 km from $|u'|_{99} |L_u$ according to $A_{99} = 1.41 |u'|_{99} |L_u$. Note that $L_u \approx \lambda/2$.

IV. Observed distribution of u-component perturbation at 12 km; $A_{99} = 1.41 |u'|_{99}$

V. Observed distribution of extreme perturbation amplitude, 99 percentile, 2-15 km

C. Two Dimensional Wind Perturbation Statistics

The development of a computational model based on Gunst and Webster's (1973) expression for the bivariate gamma (BG) distribution (BGD) is of interest in applications to wind gust modeling for the ascent flight of the Space Shuttle. Smith et al. (1982) have derived expressions for probabilities over different geometrically shaped regions. These expressions have been used for calculation of expected probabilities and cell counts within squares and equal-area sectors of the domain of the bivariate gamma distributed variables. The parameters for the BGD are calculated from absolute gust component amplitudes, $|u'|$ and $|v'|$, and associated gust lengths, L_u' and L_v' at a specified reference altitude. The goodness of fit of the model is given preliminary evaluation by comparison of the observed number of occurrences within the cells and the expected number if the variables are BG. The chi-square statistic is calculated for observed and expected cell counts ≥ 5 .

An example of the statistics calculated for VAFB-summer at 12 km for variables $|u'|$ and L_u is given in Table 3. An extensive set of tables for two wavelength bands (90-420 and 420-2470 m), in the same format, is given in Appendix A for February, April, and July at KSC and winter, transition, and summer at VAFB.

Five statistical summaries for each pair of non-dimensional variables are included in each table. The values given across the top and along the left margin are for the non-dimensional variables. These scales can be dimensionalized by dividing them by the appropriate value of B obtained from Table A1 in Appendix A. For example, as indicated in the uppermost matrix in Table 3, 3 and 4 along the top margin divided by B_{L_u} (5.0005×10^{-3} 1/m) yields values of 600 m and 800 m, respectively, for L_u and, similarly, 1 and 2 along the side margin divided by $B_{|u'|}$ (1.7866 s/m) yields .56 m/s and 1.12 m/s; thus the entry 9 in the table at the intersection of left margin value 2 and top margin 4 indicates that there are 9 occurrences of $|u'|$ between .56 and 1.12 m/s for L_u between 600 and 800 meters. The expected count, obtained from the bivariate gamma distribution, given in the second matrix yields 9.54 for the same 1x1 cell. The four numbers listed at the top of the expected cell count table are the BGD parameters ρ , γ_1 , γ_2 , and η . It is indicated that the calculated value of chi-square is based on only 8 of the possible 100 cells: this unacceptable application of chi-square can be overcome by increasing the sample

Table 3. Observed and Expected (Gamma) Cell Counts, VAFB Summer, Jhsphere, 12 km, Wavelength Range, 420-2470 m, Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * Lu$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	8	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	11	11	9	10	6	1	1	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	9	9	7	3	0	1	2	0	0	0	0	0	0	0	0	0	0	0
4	0	1	2	9	5	3	2	2	0	0	0	1	0	0	0	0	0	0	0	0
5	0	0	1	2	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
7	0	0	1	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

$B |u'| * |u'|$

Expected Cell Count

$\rho = .3578$

$\gamma_1 = 2.6448$

$\gamma_2 = 3.8826$

$\eta = .4335$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.93	4.39	5.34	3.95	2.29	1.15	.53	.23	.10	.04
2.00	.37	7.66	11.08	9.54	6.30	3.54	1.79	.84	.37	.16
3.00	.71	4.85	8.41	8.47	6.41	4.05	2.27	1.16	.56	.25
4.00	.27	2.21	4.54	5.28	4.53	3.20	1.97	1.10	.57	.28
5.00	.09	.86	2.05	2.72	2.62	2.05	1.38	.84	.47	.24
6.00	.03	.30	.82	1.24	1.33	1.14	.84	.55	.33	.18
7.00	.01	.10	.31	.52	.61	.58	.46	.33	.21	.12
8.00	.00	.03	.11	.20	.26	.27	.23	.18	.12	.08
9.00	.00	.01	.04	.07	.11	.12	.11	.09	.07	.04
10.00	.00	.00	.01	.03	.04	.05	.05	.04	.03	.02

CHI-SQUARE- 6.41015 CELLS USED- 811.E .CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00622	.03552	.07113	.09746	.11271	.12040	.12393	.12547	.12611	.12637
2.00	.01532	.09567	.20512	.29503	.35228	.38358	.39907	.40621	.40934	.41067
3.00	.02009	.13276	.29827	.44467	.54462	.60292	.63352	.64841	.65526	.65827
4.00	.02191	.14934	.34510	.52673	.65686	.73646	.78019	.80242	.81307	.81795
5.00	.02250	.15565	.36506	.56484	.71243	.80569	.85866	.88649	.90027	.90677
6.00	.02268	.15782	.37273	.58077	.73724	.83813	.89672	.92824	.94423	.95196
7.00	.02273	.15852	.37547	.58696	.74752	.85226	.91394	.94764	.96502	.97359
8.00	.02274	.15873	.37640	.58924	.75155	.85809	.92132	.95620	.97440	.98348
9.00	.02275	.15879	.37670	.59003	.75305	.86039	.92436	.95983	.97847	.98784
10.00	.02275	.15881	.37679	.59030	.75360	.86126	.92556	.96132	.98018	.98970

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	8	13	31	38	31	28	5
EXPECTED	.18233	2.27353	7.98986	16.80820	26.36406	33.12780	33.13936	23.46334	6.65151
CHI-SQUARE-	2.74946	CELLS USED=	7(1.E .CELL COUNTS GREATER THAN OR EQUAL TO 5)						
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00122	.01637	.06964	.18169	.35745	.57831	.79923	.95566	1.00000
SECTOR PROBABILITY	.00122	.01516	.05327	.11205	.17576	.22085	.22093	.15642	.04434

size, This could easily be achieved at KSC by grouping monthly data to obtain a seasonal sample that would be at least three times the size for a single month. VAFB data have already been grouped to obtain seasonal samples of 150; therefore, use of chi-square for VAFB seasonal data awaits the results of the measurement program that has been developed to support future Shuttle launches.

The third matrix contains the expected cumulative probability distribution calculated by accumulation of expected cell counts in the second table divided by the total sample count of 150; note that the expected probability associated with the 10×10 square is 98.970 percent.

The fourth matrix lists the observed and expected (BG) counts from a sample of 150 that occur in 10 degree equal-area sectors in the $|u'|$, L_u domain illustrated schematically in Figure 11.

The last matrix lists the sector probability and cumulative probability for the expected (BG) distribution.

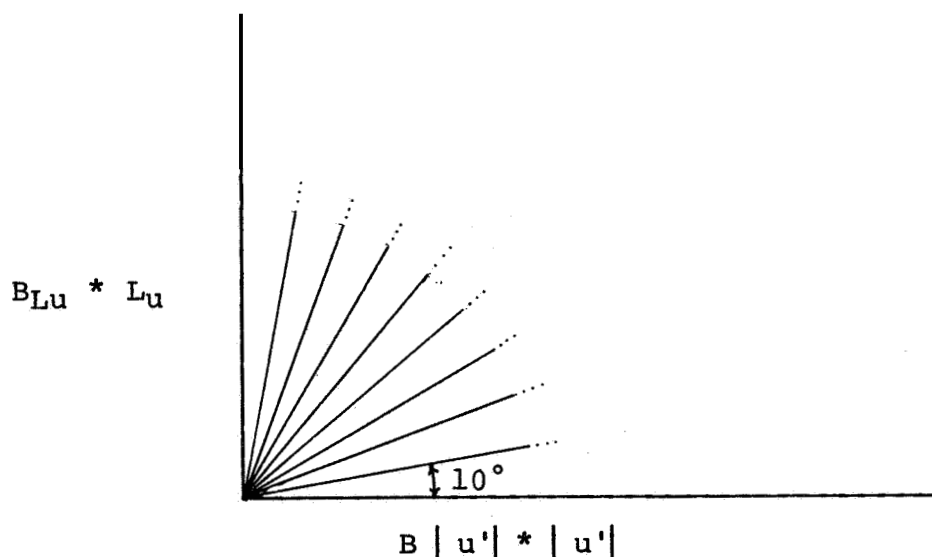


Figure 11. Schematic of Equal Area Sectors

D. Wind Component Correlation Statistics and Coordinate System Rotation

The existence of zero correlation, ρ , between wind components would greatly simplify the theoretical treatment of winds aloft statistics. When winds are defined in the standard meteorological coordinate system, the correlations are generally quite small: for example, during February at Cape Canaveral, ρ is less than .43 at all altitudes (z) below 70 km, is less than .29 for $z < 19$ km, and is less than .17 for z between 1 and 6 km.* It is generally known that, when the wind components are expressed in a coordinate system that is rotated by an angle θ with respect to the meteorological coordinate system, the correlation between the rotated wind components is periodic: i.e.,

$$\rho(\theta) = \rho(\theta + \pi) \quad (1)$$

Absolute extreme values are equivalent and the maximum and minimum values are separated by a rotation angle increment of $\pi/2$ (90 deg.). If the wind components are expressed in the meteorological coordinate system, then the rotation angle, θ_0 , required to produce zero correlation is

$$\theta_0 = \frac{1}{2} \text{ARC TAN} \left(\frac{2\rho\sigma_{\bar{x}}\sigma_{\bar{y}}}{\sigma_{\bar{y}}^2 - \sigma_{\bar{x}}^2} \right) \quad (2)$$

$$\theta_0 \leq \pi/4$$

The minimum rotation angle θ_M required to obtain the maximum correlation is dependent on the sign of ρ and θ_0 :

$$\begin{array}{ll} \text{If } \rho < 0 \text{ and } \theta_0 < 0 & \theta_M = \theta_0 - \pi/4 \\ \text{and } \theta_0 > 0 & \theta_M = \theta_0 + \pi/4 \end{array}$$

$$\begin{array}{ll} \text{If } \rho > 0 \text{ and } \theta_0 < 0 & \theta_M = \theta_0 + \pi/4 \\ \text{and } \theta_0 > 0 & \theta_M = \theta_0 - \pi/4 \end{array}$$

*Range reference atmosphere, 0-70 km, Cape Canaveral, FL, Document 361-83, RCC, White Sands Missile Range.

The rotation angle θ_{MA} required to obtain the maximum absolute correlation is:

$$\begin{aligned} \text{If } \theta_0 < 0 \quad \theta_{MA} &= \theta_0 + \pi/4 \\ \theta_0 > 0 \quad \theta_{MA} &= \theta_0 - \pi/4 \end{aligned} \quad (3)$$

The rotated correlation coefficient is given by

$$\rho_\theta = \frac{\rho \sigma_{\bar{x}} \sigma_{\bar{y}} [\sin^2 \theta - \cos^2 \theta] + \cos \theta \sin \theta (\sigma_{\bar{y}}^2 - \sigma_{\bar{x}}^2)}{\sigma_{\bar{x}\theta} \sigma_{\bar{y}\theta}} \quad (4)$$

where $\sigma_{\bar{x}\theta}$ and $\sigma_{\bar{y}\theta}$ are the rotated variances

$$\sigma_{\bar{x}\theta}^2 = \sigma_{\bar{x}}^2 \sin^2 \theta + \sigma_{\bar{y}}^2 \cos^2 \theta + 2\rho \sigma_{\bar{x}} \sigma_{\bar{y}} \cos \theta \sin \theta \quad (5)$$

$$\sigma_{\bar{y}\theta}^2 = \sigma_{\bar{y}}^2 \sin^2 \theta + \sigma_{\bar{x}}^2 \cos^2 \theta - 2\rho \sigma_{\bar{x}} \sigma_{\bar{y}} \cos \theta \sin \theta \quad (6)$$

Substitution of θ_M or θ_{MA} into Equation 4 yields the maximum correlation, ρ_M . Figure 12 illustrates unrotated and maximum absolute correlation between 0-70 km at Cape Canaveral, Florida, for an annual data sample. The unrotated values are small (<.4) and unsteady. The maximum values increase rapidly in the first 20 km; the relatively constant and large value of ρ_M between 20 and 60 km is also observed at other locations (Figure 13). Plots of θ_{MA} as a function of altitude are illustrated in Figure 14. At altitudes above 20 km, θ_{MA} is nearly constant, 40 degrees; from Equation 3, θ_0 is also nearly constant, 5 degrees. At altitudes above 20 km, the choice of orientation of the coordinate system in meteorology which describes the wind vector in terms of zonal and meridional components is near the orientation required for zero correlation.

The results summarized herein support the conclusion that significant correlation between wind components exists when winds are analyzed in non-meteorological coordinate systems. This concept has application in the engineering analysis of the impact of wind perturbations on aerospace vehicles.

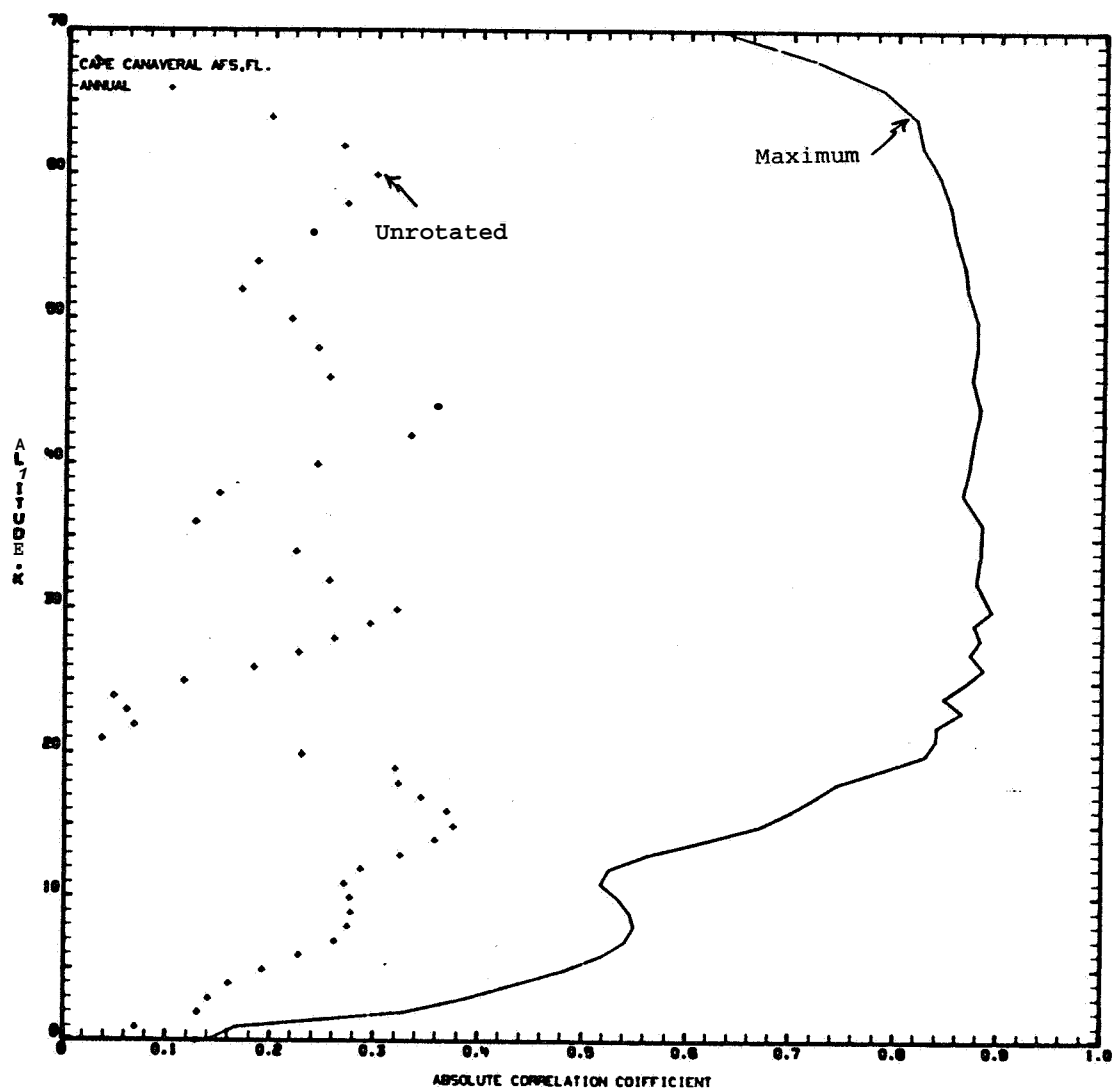


Figure 12. Unrotated and Maximum Correlation,
Cape Canaveral, Florida, Annual

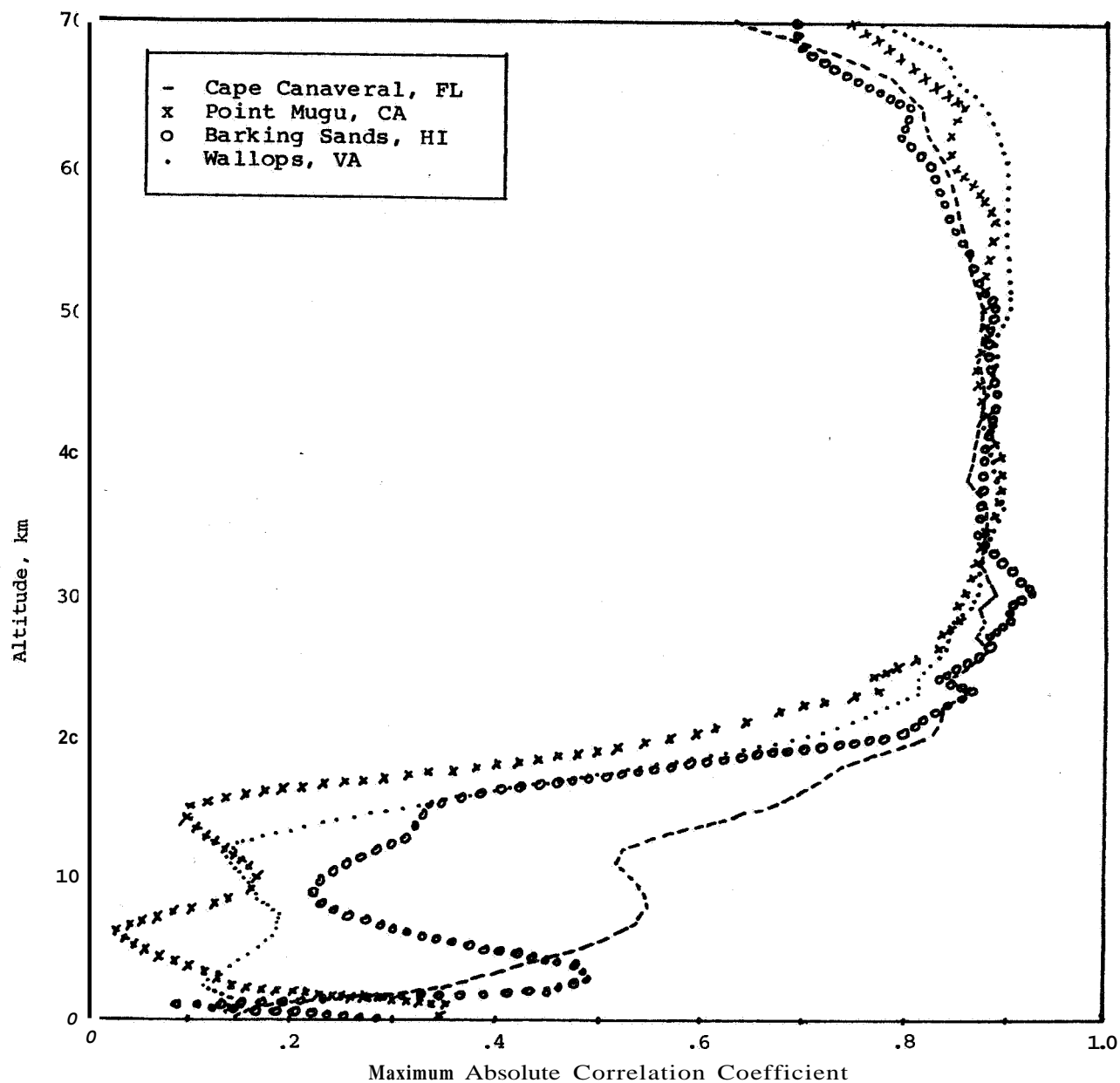


Figure 13. Maximum Wind Component Absolute Correlation Achieved by Rotation with Respect to the Meteorological Coordinate System

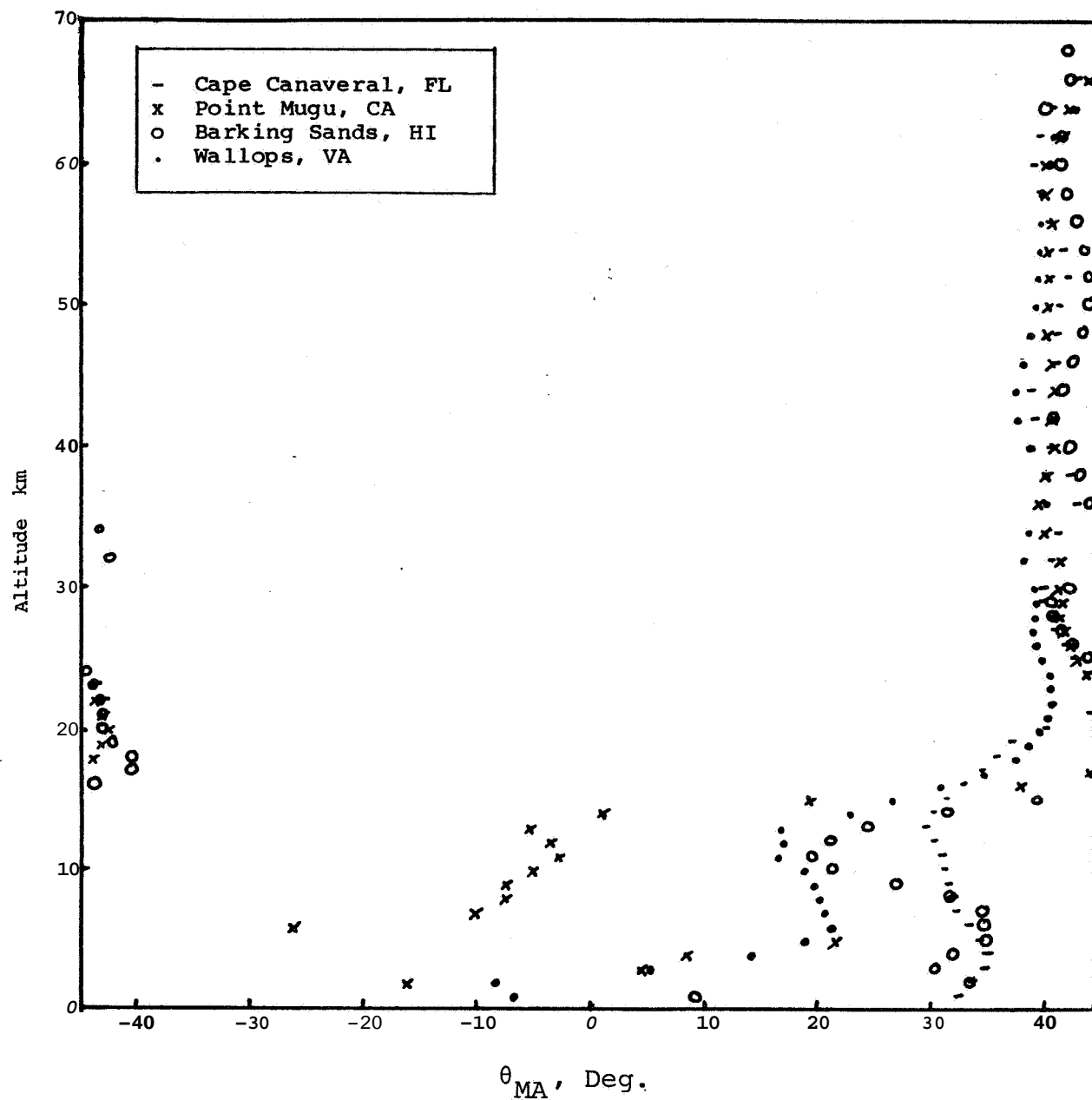


Figure 14. Rotation (Deg.) with Respect to the Meteorological Coordinate System to Achieve Maximum Wind Component Absolute Correlation for an Annual Data Sample

IV. CONCLUSIONS AND RECOMMENDATIONS

This work has produced a unique analysis of detailed wind profiles. The results have indicated significant variability of wind perturbation statistics with location, altitude, season, and wavelength range. The results provide the basis for the establishment of improved discrete gust design criteria guidelines for ascending launch vehicles. New analytical techniques and methods for evaluation of bivariate gamma probability distributions were used in the development of a vector wind gust model. These techniques may have broader application in other engineering and scientific studies.

Some aspects of the vector wind gust model present computational difficulties that may not be advantageous to future users. In its present state of development, the model does not require any simplifying assumptions. It would be useful to investigate whether simplification of the model is possible without a significant loss of accuracy. This would be accomplished by examination of sample estimates of model parameters to establish the validity of assumptions such as zero correlation or equivalence of scale or shape parameters.

It may be desirable for practical applications to use alternative models for description of gust statistics. For example, the Weibull distribution has been shown to provide a good fit to observed distributions of gust modulus. Use of a gust model based solely on gust modulus would represent an oversimplification of the nature of wind perturbations and their effect on ascending launch vehicles. Model simplification should not eliminate a description of the joint relationship between wind gust components. This joint relationship is an important consideration in selection of realistic inputs for simulation studies of vehicle control system response and resultant vehicle structural loading.

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1

APPENDIX

1

Table A1. Scale Parameter B at 12 km

		B			
		(s/m)		(1/m)	
KSC		u'	v'	L _u	L _v
FEB	I	4.3472	3.3213	2.592 E-2	2.567 E-2
	II	1.0520	1.2828	5.012 E-3	5.307 E-3
APRIL	I	6.0048	3.8315	2.988 E-2	2.213 E-2
	1.1	1.6187	1.3598	4.138 E-3	4.357 E-3
JULY	I	7.9454	10.0275	3.207 E-2	3.057 E-2
	II	2.3754	1.8363	3.977 E-3	4.933 E-3
VAFB Jimsphere					
Winter	I	3.2484	2.4363	3.520 E-2	3.050 E-2
	II	0.9712	0.9403	5.624 E-3	6.046 E-3
Transition	I	4.5208	4.0500	4.180 E-2	2.496 E-2
	II	1.1307	1.1761	5.756 E-3	4.459 E-3
Summer	I	6.2414	6.1112	3.837 E-2	2.486 E-2
	II	1.7866	2.0673	5.001 E-3	5.280 E-3

I 90 < λ < 420

II 420 < λ < 2470

Table A2. Observed and Expected (Gamma) Cell Counts, KSC February, Jimsphere. 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lu} * L_u$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |u'| * |u'|$	1	16	7	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	4	11	10	9	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	8	13	6	3	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0
	4	0	2	10	3	3	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	5	1	3	1	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .3528$ $\gamma_1 = 2.2586$ $\gamma_2 = 2.7000$ $\eta = .3914$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	5.37	10.64	7.47	3.78	1.64	.65	.24	.09	.03	.01
2.00	6.10	14.76	12.65	7.61	3.82	1.72	.72	.29	.11	.04
3.00	2.92	8.71	9.07	6.44	3.73	1.90	.89	.39	.16	.06
4.00	1.09	3.94	4.88	4.01	2.64	1.50	.77	.37	.17	.07
5.00	.36	1.56	2.25	2.11	1.54	.98	.55	.29	.14	.06
6.00	.11	.56	.94	.99	.81	.56	.34	.19	.10	.05
7.00	.03	.19	.36	.43	.39	.29	.19	.12	.07	.03
8.00	.01	.06	.13	.18	.17	.14	.10	.07	.04	.02
9.00	.00	.02	.05	.07	.07	.06	.05	.03	.02	.01
10.00	.00	.01	.02	.03	.03	.03	.02	.02	.01	.01

CHI-SQUARE = 25.80741 CELLS USED = 811 E. CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.03583	.10676	.15656	.18178	.19270	.19704	.19867	.19926	.19947	.19954
2.00	.07647	.24581	.37997	.45593	.49236	.50817	.51460	.51710	.51804	.51838
3.00	.09596	.32338	.51800	.63689	.69819	.72668	.73902	.74410	.74612	.74689
4.00	.10326	.35696	.58410	.72972	.80859	.84710	.86460	.87215	.87527	.87653
5.00	.10568	.36975	.61189	.77156	.86079	.90582	.92701	.93647	.94053	.94221
6.00	.10643	.37426	.62264	.78892	.88356	.93234	.95582	.96658	.97131	.97332
7.00	.10665	.37576	.62557	.79572	.89294	.94367	.96845	.97999	.98515	.98740
8.00	.10671	.37624	.62795	.79826	.89664	.94831	.97377	.98574	.99117	.99356
9.00	.10672	.37638	.62841	.79918	.89804	.95015	.97594	.98814	.99371	.99618
10.00	.10673	.37643	.62856	.79950	.89856	.95086	.97680	.98911	.99476	.99728

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	5	14	27	28	26	28	28	1
EXPECTED	.33687	6.97547	14.43951	27.43202	28.46312	26.38213	28.08565	28.59702	6.28841
CHI-SQUARE = 5.08574 CELLS USED = 7 (1 E. CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00891	.05541	.15168	.29456	.47098	.66019	.83410	.95808	1.00000
SECTOR PROBABILITY	.00891	.04650	.09626	.14288	.17542	.18921	.17390	.12398	.04192

Table A3, Observed and Expected (Gamma) Cell Counts. KSC February, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} \cdot L_v$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	12	10	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	16	2	4	5	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
3	0	13	11	2	8	3	1	0	2	0	0	0	0	0	0	0	0	0	0	0
4	0	2	2	4	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
5	0	3	5	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	3	0	1	3	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0
7	0	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

$B | v' | \cdot | v' |$

Expected Cell Count

$P = .2401$

$\gamma_1 = 2.4888$

$\gamma_2 = 2.8753$

$\eta = .2581$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	3.17	1.37	5.99	3.46	1.69	.75	.31	.10	.05	.02
2.00	5.10	13.10	11.83	7.55	4.05	1.96	.88	.38	.16	.06
3.00	3.26	9.32	9.41	6.64	3.91	2.05	1.00	.46	.20	.09
4.00	1.58	5.00	5.59	4.32	2.76	1.57	.82	.40	.19	.08
5.00	.67	2.33	2.86	2.41	1.66	1.01	.56	.29	.14	.07
6.00	.26	1.00	1.34	1.22	.90	.58	.34	.19	.10	.05
7.00	.10	.40	.59	.57	.45	.31	.19	.11	.06	.03
8.00	.03	.16	.25	.26	.21	.15	.10	.06	.03	.02
9.00	.01	.06	.10	.11	.10	.07	.05	.03	.02	.01
10.00	.00	.02	.04	.05	.04	.03	.02	.02	.01	.01

CHI-SQUARE = 4.81902 CELLS USED = 6 (I.E. CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.0211	.07025	.11015	.13319	.14447	.14947	.15155	.15238	.15270	.15282
2.00	.05514	.19163	.31042	.38378	.42206	.44012	.44809	.45144	.45280	.45334
3.00	.07689	.27554	.45702	.57464	.63896	.67071	.68535	.69178	.69449	.69560
4.00	.08740	.31936	.53809	.68452	.76725	.80944	.82953	.83862	.84259	.84426
5.00	.09184	.33932	.57712	.73960	.83339	.88229	.90610	.91713	.92205	.92418
6.00	.09357	.34769	.59440	.76499	.86476	.91753	.94361	.95589	.96145	.96390
7.00	.09421	.35101	.60163	.77605	.87882	.93365	.96101	.97402	.97998	.98264
8.00	.09444	.35227	.60454	.78067	.88487	.94073	.96876	.98217	.98837	.99115
9.00	.09452	.35274	.60567	.78253	.88739	.94374	.97211	.98574	.99206	.99491
10.00	.09455	.35291	.60609	.78327	.88841	.94499	.97352	.98726	.99364	.99653

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	9.98453	9.17625	13.68598	22.39586	28.86636	26.77957	24.35603	17.28690	5.46855
EXPECTED	9.98453	9.17625	13.68598	22.39586	28.86636	26.77957	24.35603	17.28690	5.46855
CHI-SQUARE	4.86688	4.86688	4.86688	4.86688	4.86688	4.86688	4.86688	4.86688	4.86688
CELLS USED	1	1	1	1	1	1	1	1	1
EXPECTED DISTRIBUTION	1	1	1	1	1	1	1	1	1
CUMULATIVE PROBABILITY	.01323	.07441	.18564	.33495	.50739	.68592	.84830	.96354	1.00000
SECTOR PROBABILITY	.01323	.06117	.11124	.14931	.17244	.17953	.16237	.11525	.03646

Table A4. Observed and Expected (Gamma) Cell Counts, KSC February, Jimsphere, 12 km. Wavelength Range, 420-2470 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

sample Size = 150

		$B_{Lu} * L_u$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B | u' | * | u' |$	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	10	13	13	4	7	0	1	0	0	0	1	0	0	0	0	0	0	0	0
	3	0	0	4	12	2	2	2	3	1	0	1	0	0	0	0	0	0	0	0	0
	4	0	0	3	3	2	4	1	1	0	0	1	0	0	0	0	0	0	0	0	0
	5	0	0	1	3	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .2990$

$\gamma_1 = 2.3407$

$\gamma_2 = 4.1985$

$\eta = .4004$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.70	4.47	8.87	8.15	4.20	2.45	1.29	.83	.29	.13
2.00	.81	5.93	10.48	10.62	8.08	5.17	2.95	1.55	.76	.36
3.00	.58	3.24	6.63	7.65	6.52	4.60	2.86	1.62	.85	.43
4.00	.11	1.35	3.19	4.15	3.93	3.04	2.05	1.25	.71	.37
5.00	.04	.50	1.33	1.93	2.02	1.71	1.25	.82	.49	.28
6.00	.01	.17	.51	.82	.94	.86	.68	.47	.30	.18
7.00	.00	.05	.18	.32	.40	.40	.34	.25	.17	.11
8.00	.00	.02	.08	.12	.16	.18	.16	.13	.09	.06
9.00	.00	.00	.02	.04	.06	.07	.06	.05	.05	.03
10.00	.00	.00	.01	.02	.02	.03	.03	.03	.02	.02

CHI-SQUARE= 7.61953 CELLS USED= 7 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00467	.03445	.08025	.12123	.14922	.16554	.17412	.17831	.18027	.18114
2.00	.01005	.07938	.19508	.30684	.38872	.43950	.46771	.48221	.48925	.49252
3.00	.01250	.10350	.26341	.42620	.55153	.63299	.68026	.70555	.71828	.72440
4.00	.01349	.11345	.29459	.48504	.63654	.73829	.79925	.83288	.85032	.85893
5.00	.01378	.11705	.30705	.51038	.67536	.78850	.85777	.89685	.91755	.92800
6.00	.01387	.11825	.31162	.52041	.69165	.81054	.88433	.92656	.94929	.96094
7.00	.01389	.11853	.31321	.52416	.69809	.81965	.89570	.93963	.96350	.97587
8.00	.01390	.11875	.31374	.52549	.70052	.82326	.90037	.94514	.96962	.98239
9.00	.01390	.11878	.31391	.52595	.70141	.82464	.90222	.94738	.97216	.98515
10.00	.01390	.11879	.31396	.52610	.70172	.82515	.90293	.94827	.97320	.98629

Observed and Expected (Gamma) Counts within Equal Area Sectors

'Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	1	14	18	32	36	42	7
EXPECTED	.08164	1.22708	4.87272	11.44843	20.30355	29.63358	35.90748	32.96873	13.55881
CHI-SQUARE= 6.66718 CELLS USED= 6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00054	.00872	.04121	.11753	.25289	.45045	.68983	.90961	1.00000
SECTOR PROBABILITY	.00054	.00818	.03248	.07632	.13538	.19756	.23938	.21978	.09039

Table AS. Observed and Expected (Gamma) Cell Counts, KSC February.
Jhsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lv} * L_v$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |v'| * |v'|$	1	3	6	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	2	8	4	4	1	2	3	1	0	0	0	0	0	0	0	0	0	0	0
	3	0	2	6	3	6	11	3	5	2	1	1	0	0	0	0	0	0	0	0	0
	4	0	0	6	4	8	2	3	4	0	2	0	0	0	0	0	0	0	0	0	0
	5	0	0	2	5	3	3	3	1	2	0	0	0	0	0	0	0	0	0	3	0
	6	0	0	0	2	2	3	1	2	1	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .3064$	$\gamma_1 = 3.1086$	$\gamma_2 = 4.6700$	$\eta = .3707$							
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.14	1.21	2.21	2.20	1.60	.98	.53	.26	.12	.05
2.00	.35	3.33	6.82	7.54	6.06	4.02	2.35	1.25	.62	.29
3.00	.26	2.83	6.57	8.15	7.28	5.29	3.35	1.92	1.03	.52
4.00	.13	1.61	4.21	5.81	5.71	4.53	3.11	1.92	1.09	.58
5.00	.05	.75	2.19	3.35	3.60	3.10	2.29	1.51	.92	.52
6.00	.02	.31	1.00	1.68	1.97	1.83	1.45	1.02	.66	.39
7.00	.01	.12	.38	.77	.99	.90	.83	.62	.42	.27
8.00	.00	.04	.17	.33	.45	.48	.44	.35	.25	.16
9.00	.00	.01	.06	.13	.20	.23	.22	.18	.14	.09
10.00	.00	.00	.02	.05	.08	.10	.10	.09	.07	.05

CHI-SQUARE = 6.6686 CELLS USED = 511 E.C. CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.0009	.0049	.0231	.0383	.0405	.0555	.0506	.0681	.0612	.0619
2.00	.0035	.0337	.0916	.1543	.2034	.2470	.2815	.3074	.3271	.3394
3.00	.0049	.0541	.1911	.2731	.3760	.4451	.4863	.5045	.5216	.5274
4.00	.0058	.0637	.1978	.3577	.4935	.5921	.6540	.6912	.7092	.7185
5.00	.0062	.0711	.2179	.3980	.5580	.6795	.7568	.8038	.8275	.8406
6.00	.0063	.0733	.2267	.4181	.5928	.7245	.8117	.8645	.8932	.9063
7.00	.0064	.0742	.2302	.4269	.6083	.7463	.8390	.8958	.9284	.9457
8.00	.0064	.0744	.2316	.4305	.6147	.7561	.8518	.9101	.9449	.9633
9.00	.0064	.0745	.2320	.4319	.6174	.7603	.8575	.9178	.9523	.9719
10.00	.0064	.0745	.2323	.4324	.6185	.7623	.8599	.9209	.9562	.9757

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

		1	2	3	4	5	6	7	8	9
OBSERVED EXPECTED		0	0	5	22	26	30	39	26	2
		.09091	1.6666	7.1813	16.6667	27.3850	25.1372	34.6320	22.4308	4.8433
		CHI-SQUARE = 4.35571 CELLS USED = 611 E.C. CELL COUNTS GREATER THAN OR EWU TO 5)								
		EXPECTED DISTRIBUTION								
		10.	20.	30.	40.	50.	60.	70.	80.	90.
		.00061	.01190	.05978	.17048	.35304	.58729	.81817	.96771	1.00000
		.00061	.01130	.04788	.11070	.18257	.23425	.23088	.14954	.03229

Table A6. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lu} * Lu$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |u'| * |u'|$	1	11	8	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	13	9	9	6	7	1	2	1	0	0	0	0	0	0	0	0	0	0	0
	3	0	3	8	9	7	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	1	4	4	4	4	3	0	1	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	2	5	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .3985$ $\gamma_1 = 2.3865$ $\gamma_2 = 3.5184$ $\eta = .4839$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	2.14	7.45	7.35	4.66	2.40	1.09	.46	.19	.07	.03
2.00	2.32	10.29	12.74	9.76	5.85	3.02	1.42	.62	.26	.11
3.00	.98	5.58	8.69	8.06	5.66	3.34	1.75	.84	.38	.17
4.00	.31	2.25	4.30	4.75	3.87	2.59	1.52	.81	.40	.18
5.00	.09	.77	1.79	2.31	2.16	1.63	1.06	.62	.33	.17
6.00	.02	.24	.66	.99	1.05	.89	.64	.41	.24	.13
7.00	.01	.07	.23	.39	.47	.44	.35	.24	.15	.09
8.00	.00	.02	.07	.14	.19	.20	.17	.13	.09	.05
9.00	.00	.01	.02	.05	.07	.06	.06	.05	.05	.03
10.00	.00	.00	.01	.02	.03	.03	.03	.03	.02	.02

CHI-SQUARE = 2.40191 CELLS USED = 4 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01424	.05389	.11289	.14399	.15997	.16726	.17036	.17162	.17211	.17231
2.00	.02972	.14794	.28190	.37810	.44307	.46051	.47395	.47845	.48068	.48157
3.00	.03625	.19167	.38358	.53352	.62623	.67595	.70018	.71122	.71599	.71799
4.00	.03833	.25873	.42933	.61091	.72940	.79640	.84076	.84716	.85458	.85740
5.00	.03891	.21448	.44701	.64402	.77691	.84480	.89624	.91676	.92639	.93071
6.00	.03906	.21624	.45320	.65146	.79676	.84059	.87631	.94956	.96077	.96594
7.00	.03910	.21675	.45522	.66146	.80449	.89123	.93926	.96412	.97634	.98209
8.00	.03910	.21688	.45544	.66303	.80733	.89539	.94456	.97028	.98308	.98919
9.00	.03911	.21692	.45602	.66354	.80833	.89695	.94664	.97279	.98590	.99222
10.00	.03911	.21693	.45608	.66370	.80866	.89750	.94762	.97377	.98704	.99347

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
	0	1	5	19	23	35	39	21	1
OBSERVED									
EXPECTED	.23200	2.45327	8.11915	16.71816	25.97458	32.45585	32.55269	23.81299	7.68131
CHI-SQUARE =	3.75328								
CELLS USED =	5 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)								
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00155	.01790	.07203	.18348	.35654	.57302	.79004	.94679	1.00000
SECTOR PROBABILITY	.00155	.21636	.25413	.11145	.17316	.21677	.21702	.15875	.05121

Table A7. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphare, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		B _{Lv} * L _v																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B $|v'|$ * $|v'|$	1	16	5	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	4	13	15	7	6	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0
	3	3	3	13	8	8	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	4	2	5	5	4	4	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .2287$

$\gamma_1 = 2.1858$

$\gamma_2 = 2.7620$

$\eta = .2571$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	4.87	10.53	4.26	4.72	2.31	1.03	.43	.17	.07	.03
2.00	5.96	14.26	12.50	7.98	4.72	2.05	.93	.40	.17	.07
3.00	3.26	8.73	4.55	5.11	7.50	1.84	.90	.42	.19	.08
4.00	1.93	4.24	4.60	3.52	7.24	1.27	.66	.33	.15	.07
5.00	.56	1.84	2.19	1.42	1.25	.75	.42	.22	.11	.05
6.00	.21	.74	.97	.87	.64	.41	.24	.13	.07	.03
7.00	.07	.29	.41	.19	.33	.21	.13	.07	.04	.02
8.00	.02	.11	.16	.17	.14	.11	.06	.04	.02	.01
9.00	.01	.04	.06	.07	.06	.05	.03	.02	.01	.01
10.00	.00	.01	.02	.03	.03	.02	.01	.01	.01	.00

CHI-SQUARE = 7.24976 CELLS USED = 7 (I.F., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.63250	.10272	.15795	.14944	.27442	.21167	.21455	.21571	.21617	.21634
2.00	.67220	.23750	.37607	.45612	.50364	.52414	.53321	.53705	.53982	.54024
3.00	.69396	.31743	.51303	.61697	.73370	.77647	.78154	.78415	.78495	.78512
4.00	.70347	.35519	.58149	.72476	.81043	.84575	.85175	.85202	.85205	.85205
5.00	.70720	.37116	.61208	.77152	.85147	.90723	.91011	.91016	.91016	.91016
6.00	.70858	.37747	.62445	.79008	.88437	.93335	.94724	.94817	.94817	.94817
7.00	.70906	.37986	.62994	.79777	.89409	.94446	.94920	.94982	.94982	.94982
8.00	.70922	.38074	.63190	.80085	.89610	.94913	.94913	.94913	.94913	.94913
9.00	.70928	.38105	.63264	.80205	.89771	.95105	.94943	.94943	.94943	.94943
10.00	.70930	.38116	.63291	.80251	.89834	.95182	.94910	.94910	.94910	.94910

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	1	7	13	16	25	39	25	23	1
EXPECTED	1.87488	9.19029	14.71442	20.02629	23.89242	25.07274	25.73194	20.92166	8.56736
CHI-SQUARE = 7.67176 CELLS USED = 7 (I.F., CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.01253	.06713	.16525	.29976	.45904	.61146	.76341	.91488	1.00000
SECTOR PROBABILITY	.01253	.05460	.09912	.13351	.15928	.17182	.17155	.13948	.05712

Table A8. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * L_u$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	7	3	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	8	9	5	1	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0
3	0	3	5	8	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	1	8	9	4	3	2	3	2	1	0	0	0	0	0	0	0	0	0	0
5	0	1	9	8	5	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
6	0	0	4	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	5	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .2625$ $\gamma_1 = 3.2219$ $\gamma_2 = 3.5734$ $\eta = .2764$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.54	2.27	2.50	1.75	.98	.48	.21	.09	.04	.01
2.00	1.68	7.15	8.67	6.65	4.06	2.16	1.05	.17	.20	.08
3.00	1.50	7.05	9.47	8.01	5.35	3.09	1.62	.79	.36	.16
4.00	.90	4.64	6.88	6.17	4.62	2.88	1.62	.94	.41	.19
5.00	.44	2.50	4.06	4.79	3.20	2.14	1.28	.71	.47	.18
6.00	.19	1.19	2.11	2.30	1.93	1.38	.88	.51	.28	.15
7.00	.08	.52	1.01	1.18	1.06	.80	.54	.33	.19	.10
8.00	.03	.22	.45	.57	.54	.43	.31	.20	.12	.07
9.00	.01	.09	.19	.26	.26	.22	.16	.11	.07	.04
10.00	.00	.03	.08	.11	.12	.11	.08	.06	.04	.02

CUM-SQUARES = 1.00000 CELLS USED = 711.0, CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00387	.01901	.03567	.04734	.05386	.05795	.05848	.05908	.05933	.05941
2.00	.01506	.07787	.15231	.20833	.24192	.25950	.26790	.27167	.27328	.27391
3.00	.02506	.13485	.27242	.38194	.45108	.48926	.50846	.51748	.52152	.52322
4.00	.03105	.17177	.35519	.50706	.60710	.66449	.69448	.70912	.71592	.71889
5.00	.03399	.19137	.40186	.58099	.70236	.77402	.81255	.83193	.84118	.84544
6.00	.03527	.20060	.42517	.61963	.75388	.83471	.87909	.90188	.91299	.91882
7.00	.03579	.20461	.43590	.63823	.77954	.86571	.91368	.93868	.95106	.95699
8.00	.03599	.20626	.44056	.64666	.79157	.88063	.93064	.95696	.97019	.97644
9.00	.03606	.20690	.44249	.65031	.79696	.88749	.93859	.96565	.97929	.98599
10.00	.03609	.20715	.44326	.65193	.79929	.89053	.94219	.96964	.98353	.99031

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	2	15	33	30	28	25	15	2
EXPECTED	1.00157	7.37967	16.90881	25.23624	29.96561	29.80054	24.00736	13.21130	2.49285
CHI-SQUARE	2.99514	CELLS USED:	611.0, CELL COUNTS GREATER THAN OR EQUAL TO 51	EXPECTED 01570180710M					
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00668	.05547	.16857	.33682	.53659	.73526	.89531	.99338	1.00000
SECTOR PROBABILITY	.00668	.04920	.11270	.16824	.19977	.19867	.16005	.08808	.01662

Table A9. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} * L_v$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |v'| * |v'|$	1	3	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	14	4	6	7	3	3	0	1	0	0	0	0	0	0	0	0	0	0
	3	0	4	11	8	3	1	1	2	0	1	0	0	0	0	0	0	0	0	0
	4	0	0	3	7	8	3	3	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	1	1	14	3	0	0	2	1	0	0	0	0	0	0	0	0	0	0
	6	0	0	3	6	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	8	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .2242$

$\gamma_1 = 3.0288$

$\gamma_2 = 3.7219$

$\eta = .2485$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.55	2.51	3.13	2.43	1.49	.79	.39	.18	.08	.03
2.00	1.39	6.83	9.20	7.70	5.07	2.89	1.50	.73	.33	.15
3.00	1.17	6.19	9.08	8.23	5.85	3.58	1.98	1.02	.49	.23
4.00	.68	3.88	6.17	6.34	4.60	3.70	1.76	.96	.49	.24
5.00	.33	2.02	3.48	3.65	2.97	2.06	1.28	.73	.39	.20
6.00	.14	.95	1.75	1.97	1.70	1.24	.81	.49	.27	.15
7.00	.06	.41	.81	.98	.89	.69	.47	.30	.17	.10
8.00	.02	.17	.36	.46	.44	.36	.26	.17	.10	.06
9.00	.01	.07	.15	.20	.21	.18	.13	.09	.06	.03
10.00	.00	.03	.06	.09	.09	.08	.07	.05	.03	.02

CHI-SQUARE= 9.19109 CELLS USED= 611.E..CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00366	.02040	.04125	.05743	.06736	.07266	.07524	.07642	.07693	.07714
2.00	.01296	.07525	.15745	.22497	.26871	.29330	.30588	.31190	.31463	.31593
3.00	.02075	.12433	.26705	.38946	.47217	.52060	.54636	.55916	.56519	.56792
4.00	.02525	.15469	.33854	.50120	.61456	.68298	.72049	.73967	.74897	.75331
5.00	.02743	.17036	.37739	.56440	.69756	.77970	.82572	.84977	.86170	.86738
6.00	.02838	.17760	.39630	.59642	.74089	.83133	.88277	.91008	.92384	.93049
7.00	.02876	.18072	.40485	.61147	.76190	.85692	.91151	.94080	.95572	.96372
8.00	.02891	.18200	.40852	.61818	.77154	.86895	.92525	.95565	.97126	.97896
9.00	.02896	.18250	.41003	.62105	.77579	.87437	.93155	.96256	.97855	.98647
10.00	.02898	.18269	.41063	.62224	.77760	.87674	.93435	.96567	.98186	.98991

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	3	9	27	32	37	27	18	1
EXPECTED	-121193	5.79453	15.011572	22.16125	29.09589	30.33578	27.24984	17.47544	4.11063
CHI-SQUARE=	5.55125								
CELLS USED=									
EXPECTED DISTRIBUTION									
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00463	.04346	.13710	.28478	.47219	.67443	.85669	.97260	1.00000
SECTOR PROBABILITY	.00463	.03863	.09364	.14778	.18731	.22224	.18167	.11650	.02740

Table A10. Observed and Expected (Gamma) Cell Counts, KSC July, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lu} * Lu$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |u'| * |u'|$	1	10	9	3	4	6	3	0	1	1	1	0	1	0	0	0	0	0	0	0	0
	2	0	7	10	10	7	5	2	1	1	1	0	1	0	0	0	0	0	0	0	0
	3	0	3	7	6	8	7	1	2	1	0	0	0	0	0	0	0	0	0	0	0
	4	0	1	2	9	4	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	1	3	1	2	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0
	6	0	2	3	2	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .4053$ $\gamma_1 = 2.3808$ $\gamma_2 = 3.6733$ $\eta = .5034$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	1.76	6.99	7.44	4.97	2.66	1.26	.65	.23	.09	.04
2.00	1.85	9.32	12.64	10.17	6.35	3.39	1.64	.74	.32	.13
3.00	.74	4.86	8.25	8.18	6.01	3.68	1.99	.98	.45	.20
4.00	.22	1.87	3.96	4.69	4.02	2.80	1.69	.92	.46	.22
5.00	.06	.62	1.59	2.22	2.19	1.73	1.17	.70	.38	.20
6.00	.01	.18	.57	.92	1.04	.93	.69	.46	.27	.15
7.00	.00	.05	.19	.35	.45	.44	.37	.26	.17	.10
8.00	.00	.01	.06	.12	.18	.20	.16	.14	.10	.06
9.00	.00	.00	.02	.04	.07	.09	.08	.07	.05	.03
10.00	.00	.00	.00	.01	.02	.03	.03	.03	.03	.02

CHI-SQUARE= 3.1735 CELLS USED= 3 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01189	.05848	.10807	.14173	.15998	.16776	.17103	.17256	.17318	.17343
2.00	.02422	.11294	.26612	.36725	.44714	.49275	.51919	.54192	.56192	.57833
3.00	.02916	.17025	.35967	.51412	.61431	.66996	.71071	.74646	.77691	.80303
4.00	.03065	.18424	.39909	.58578	.71275	.78696	.82612	.84576	.85411	.85803
5.00	.03104	.18875	.41421	.61573	.75727	.84304	.88996	.91376	.92517	.93038
6.00	.03114	.19008	.41933	.62096	.77551	.86744	.91897	.94581	.95902	.96523
7.00	.03116	.19044	.42094	.62393	.78245	.87734	.92131	.94991	.96426	.96814
8.00	.03116	.19054	.42142	.62424	.78494	.88113	.92679	.95591	.96881	.97180
9.00	.03116	.19056	.42156	.62465	.78579	.88252	.92870	.95619	.96852	.97155
10.00	.03117	.19057	.42160	.62477	.78607	.88300	.92892	.95610	.96841	.97126

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	3	6	10	26	33	43	20	9
EXPECTED	.14929	1.84107	6.79702	15.19964	25.10489	32.84246	34.06905	25.56792	8.43872
CHI-SQUARE= 5.49024 CELLS USED= 7 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00100	.01327	.05858	.15945	.32721	.54616	.77329	.94374	1.00000
SECTOR PROBABILITY	.00100	.01227	.04431	.10176	.16737	.21895	.22713	.17045	.05626

Table All. Observed and Expected (Gamma) Cell Counts, KSC July,
Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} \cdot L_v$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	3	5	1	1	1	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0
2	3	7	7	7	5	2	2	0	7	0	0	0	0	0	0	0	0	0	0	0
3	0	1	5	9	8	7	6	1	1	1	0	1	0	0	0	0	0	0	0	0
4	0	0	4	4	5	4	2	1	0	0	1	0	0	0	0	0	0	0	0	0
5	0	0	1	3	5	5	3	2	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	1	2	2	3	2	0	0	1	0	0	0	0	0	0	0	0	0	0
7	0	0	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

$B | v' | * | v' |$

Expected Cell Count

$P = .3321$ $Y_1 = 2.9943$ $Y_2 = 4.3395$ $n = .3998$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.31	2.08	3.19	2.78	1.83	1.02	.61	.24	.11	.04
2.00	.64	4.86	4.54	4.45	5.22	3.83	2.79	1.75	.50	.22
3.00	.92	3.73	7.55	4.53	7.06	4.82	2.89	1.57	.80	.38
5.00	.19	1.93	4.52	5.80	5.36	4.03	2.64	1.56	.85	.43
6.00	.07	.84	2.23	3.21	3.28	2.71	1.92	1.22	.71	.39
7.00	.02	.32	.97	1.56	1.75	1.57	1.21	.92	.51	.30
8.00	.01	.11	.39	.69	.85	.82	.68	.50	.33	.21
9.00	.00	.04	.15	.26	.38	.40	.35	.28	.19	.13
10.00	.00	.01	.05	.11	.16	.16	.17	.14	.11	.07
10.00	.00	.00	.02	.04	.07	.08	.08	.07	.05	.04

CHI-SQUARE = 1.80286 CELLS USED = 7 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 70 E)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00208	.01595	.03720	.05573	.06792	.07472	.07812	.07971	.08041	.08071
2.00	.00634	.05259	.13080	.20565	.25933	.29161	.30896	.31755	.32156	.32334
3.00	.00913	.03005	.20856	.34029	.44094	.50542	.54271	.56110	.57043	.57476
4.00	.01038	.04420	.25296	.42333	.55974	.65107	.70535	.73671	.74969	.75693
5.00	.01086	.10025	.27391	.46566	.62393	.73330	.80209	.83789	.85762	.86745
6.00	.01102	.10256	.28270	.48442	.65476	.77461	.84965	.89273	.91589	.92770
7.00	.01107	.10337	.28611	.49242	.66840	.79375	.87333	.91973	.94508	.95823
8.00	.01108	.10365	.28736	.49595	.67408	.80209	.88473	.93227	.95801	.97290
9.00	.01109	.10373	.28779	.49713	.67633	.80556	.88865	.93733	.96518	.97965
10.00	.01109	.10376	.28794	.49755	.67718	.80694	.89056	.94071	.96792	.98266

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	7	17	30	79	17	47	8
EXPECTED	.12289	1.95145	7.67422	17.04876	27.41285	34.56927	33.80873	22.22768	5.18484
CHI-SQUARE = 7.57823 CELLS USED = 7 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5) EXPECTED DISTRIBUTION									
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00082	.01383	.06499	.17864	.36140	.59186	.81725	.96543	1.00000
SECTOR PROBABILITY	.00062	.01301	.05116	.11365	.18275	.23046	.22539	.14818	.03457

Table A12. observed and Expected (Gamma) Cell Counts, KSC July, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * L_u$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	8	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	10	9	5	3	1	1	2	0	0	1	0	0	0	0	0	0	0	0	0
3	0	0	7	7	8	5	3	5	0	0	0	0	0	0	0	0	0	0	0	0
4	0	1	8	7	5	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0
5	0	0	3	8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

$B | u' | * | u' |$

Expected Cell Count

$\rho = .2955$ $\gamma_1 = 2.9129$ $\gamma_2 = 3.6080$ $\eta = .3289$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.87	3.44	3.80	2.65	1.48	.72	.32	.14	.05	.02
2.00	1.85	8.19	10.20	7.97	4.92	2.64	1.29	.59	.25	.11
3.00	1.32	6.64	9.41	8.76	5.67	3.35	1.78	.88	.41	.16
4.00	.66	3.76	6.01	5.88	4.45	2.86	1.65	.87	.44	.21
5.00	.28	1.78	3.19	3.44	2.85	1.99	1.23	.70	.37	.19
6.00	.11	.76	1.50	1.78	1.60	1.20	.80	.46	.27	.14
7.00	.04	.30	.65	.85	.82	.66	.47	.30	.18	.10
8.00	.01	.11	.27	.38	.39	.34	.25	.17	.11	.06
9.00	.00	.04	.11	.16	.18	.16	.13	.09	.06	.04
10.00	.00	.01	.04	.06	.08	.07	.06	.05	.03	.02

CHI-SQUARE = 5.11395 CELLS USED = 9 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00581	.02877	.05409	.07176	.08159	.08639	.08854	.08944	.08981	.08995
2.00	.01813	.09572	.18904	.25984	.30250	.32489	.33541	.34042	.34248	.34372
3.00	.02695	.14882	.30495	.43075	.51123	.55592	.57850	.58915	.59393	.59599
4.00	.03137	.17834	.37445	.53958	.64973	.71352	.74709	.76357	.77125	.77468
5.00	.03323	.19209	.40944	.59753	.72667	.80739	.84546	.86660	.87674	.88141
6.00	.03394	.19785	.42522	.62520	.76500	.85004	.89711	.92146	.93340	.93902
7.00	.03419	.20010	.43183	.63746	.74273	.82216	.87235	.90468	.91840	.92606
8.00	.03428	.20093	.43446	.64259	.74048	.84216	.89404	.91651	.92535	.92804
9.00	.03430	.20123	.43546	.64466	.74373	.84650	.89923	.91732	.92155	.92450
10.00	.03431	.20133	.43582	.64546	.74504	.84831	.89146	.90986	.91431	.91719

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	61512	517160	1335374	2210425	2876173	3119594	2759116	1719797
EXPECTED	0	61512	517160	1335374	2210425	2876173	3119594	2759116	1719797
CHI-SQUARE =	6.34115	CELLS USED =	5 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)						
EXPECTED DISTRIBUTION									
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00410	.03858	.12760	.27496	.46671	.67468	.84862	.97328	1.00000
SECTOR PROBABILITY	.00410	.03448	.08902	.14776	.19174	.20707	.18394	.11465	.02672

Table A13. Observed and Expected (Gamma) Cell Counts, KSC July, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} \cdot L_v$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6	15	5	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	6	8	5	6	7	7	1	1	1	0	0	0	0	0	0	0	0	0	0
3	0	0	4	9	6	17	4	1	2	0	0	0	0	0	0	0	0	0	0	0
4	0	0	5	4	7	1	3	1	2	0	1	0	0	0	0	0	0	0	0	0
5	0	0	1	2	1	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

$B |v'| \cdot |v'|$

Expected Cell Count

$\rho = .3761$ $\gamma_1 = 2.3066$ $\gamma_2 = 4.1676$ $\eta = .5055$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.90	5.33	7.58	6.30	4.02	2.71	1.10	.51	.23	.10
2.00	.85	6.29	11.74	10.94	4.75	4.96	2.71	1.36	.65	.29
3.00	.32	2.99	6.54	7.77	5.66	4.65	2.83	1.56	.80	.38
4.00	.09	1.08	2.87	4.75	4.70	3.16	2.14	1.29	.71	.37
5.00	.02	.33	1.08	1.77	2.01	1.76	1.74	.88	.53	.29
6.00	.01	.10	.36	.69	.89	.88	.73	.53	.34	.20
7.00	.00	.03	.11	.25	.36	.40	.36	.28	.20	.13
8.00	.00	.01	.03	.08	.14	.17	.16	.14	.11	.07
9.00	.00	.00	.01	.03	.05	.06	.07	.06	.05	.04
10.00	.00	.00	.00	.01	.02	.02	.03	.03	.02	.02

CHI-SQUARE = 23.25596 CELLS USED = 6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00602	.04158	.09212	.13411	.16092	.17562	.18295	.18637	.18790	.18856
2.00	.01168	.08918	.21335	.32626	.40876	.45651	.48148	.49440	.50324	.50726
3.00	.01380	.11125	.27899	.44572	.57062	.64938	.69364	.71654	.72769	.73287
4.00	.01440	.11903	.30592	.49963	.65122	.75109	.80961	.84112	.85704	.86468
5.00	.01456	.12141	.31548	.52100	.68597	.79773	.86517	.90257	.92202	.93163
6.00	.01459	.12208	.31856	.52869	.69959	.81724	.88556	.93048	.95221	.96318
7.00	.01460	.12226	.31949	.53127	.70457	.82447	.89959	.94240	.96546	.97729
8.00	.01460	.12230	.31976	.53209	.70629	.82769	.90351	.94726	.97103	.98334
9.00	.01460	.12231	.31983	.53234	.70686	.82868	.90497	.94915	.97328	.98584
10.00	.01460	.12232	.31985	.53241	.70704	.82902	.90550	.94987	.97415	.98685

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	3	9	19	40	35	36	11
EXPECTED	.04608	.62761	3.90776	10.53877	20.46072	31.04585	37.40571	32.85693	12.87057
CHI-SQUARE = 6.05256 CELLS USED = 6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00031	.00582	.03188	.10213	.23854	.44578	.69815	.91420	1.00000
SECTOR PROBABILITY	.00031	.00582	.02605	.07076	.13640	.20724	.24937	.21905	.08580

Table A14. Observed and Expected (Gamma) Cell Counts, VAFB Winter, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * L_u$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |u'| * |u'|$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$P = .3348$

$\gamma_1 = 2.0788$

$\gamma_2 = 4.7338$

$\eta = .5052$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.42	3.97	7.16	8.37	6.55	4.27	2.47	1.32	.68	.32
2.00	.31	3.57	8.53	10.69	9.55	6.94	4.39	2.52	1.35	.68
3.00	.10	1.44	4.18	6.23	6.37	5.21	3.65	2.28	1.31	.71
4.00	.03	.46	1.60	2.78	3.66	3.99	2.31	1.58	.98	.56
5.00	.01	.13	.54	1.08	1.44	1.48	1.26	.93	.62	.38
6.00	.00	.03	.17	.38	.57	.65	.61	.49	.35	.23
7.00	.00	.01	.05	.13	.21	.27	.24	.18	.13	.08
8.00	.00	.00	.01	.06	.07	.10	.11	.09	.07	.03
9.00	.00	.00	.00	.01	.01	.04	.05	.04	.03	.02
10.00	.00	.00	.00	.00	.01	.01	.02	.02	.02	.02

CHI-SQUARE = 9.80593 CELLS USED = 711 E., CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00282	.02926	.08150	.13730	.18099	.20947	.22597	.23477	.23920	.24132
2.00	.00489	.05513	.16426	.29134	.39871	.47347	.51926	.54489	.55831	.56498
3.00	.00555	.06537	.20239	.37079	.52062	.63012	.70022	.74104	.76319	.77457
4.00	.00572	.06860	.21630	.40327	.57482	.70428	.78981	.84116	.86982	.88495
5.00	.00578	.06930	.22079	.41492	.59612	.73542	.82932	.88089	.91971	.93739
6.00	.00577	.06973	.22213	.41880	.60384	.74749	.84547	.90631	.94150	.96074
7.00	.00577	.06979	.22231	.42002	.60647	.75190	.85169	.91413	.95053	.97066
8.00	.00578	.06981	.22261	.42038	.60732	.75343	.85399	.91714	.95416	.97472
9.00	.00578	.06981	.22263	.42048	.60759	.75395	.85480	.91826	.95556	.97633
10.00	.00578	.06981	.22264	.42052	.60767	.75411	.85508	.91866	.95607	.97695

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	1	2	11	26	40	53	17
EXPECTED	.00978	.26735	1.67538	5.86824	13.51680	25.17894	37.87198	42.69010	23.32185
CHI-SQUARE =	4.84266								
CELLS USED =									
EXPECTED DISTRIBUTION									
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00007	.00185	.01302	.05080	.14092	.30878	.55932	.84432	1.00000
SECTOR PROBABILITY	.00007	.00178	.01117	.03779	.09011	.16786	.25115	.28460	.15548

Table A15. Observed and Expected (Gamma) Cell Counts, VAFB Winter, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		B _{L_V} * L _V																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B [v] * [v']	1	7	14	12	5	9	3	2	0	0	0	1	0	0	0	0	0	0	0	0	0
	2	0	3	11	13	6	5	2	2	0	0	1	0	0	0	0	0	0	0	0	0
	3	0	0	3	9	3	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	1	2	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

		$\rho = .3205$ $\gamma_1 = 1.6875$ $\gamma_2 = 3.0769$ $\eta = .4858$									
		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	2.02	10.42	14.10	11.65	7.55	4.25	2.18	1.05	.49	.22	
2.00	1.04	6.71	11.17	10.93	8.11	5.09	2.86	1.48	.73	.34	
3.00	.29	2.39	4.89	5.65	4.83	3.41	2.11	1.19	.62	.31	
4.00	.07	.72	1.78	2.91	2.35	1.86	1.27	.78	.44	.23	
5.00	.02	.20	.58	.92	1.01	.83	.67	.45	.27	.15	
6.00	.00	.05	.18	.32	.40	.39	.32	.23	.15	.09	
7.00	.00	.01	.05	.11	.15	.16	.14	.11	.08	.05	
8.00	.00	.00	.01	.03	.05	.06	.06	.05	.04	.03	
9.00	.00	.00	.00	.01	.02	.02	.02	.02	.02	.01	
10.00	.00	.00	.00	.00	.01	.01	.01	.01	.01	.01	

CHI-SQUARE = 7.99917 CELLS USED= 811.E., CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01347	.08292	.17692	.25459	.30492	.33323	.34777	.35479	.35802	.35947
2.00	.02030	.13454	.30300	.45353	.55796	.62022	.65382	.67072	.67879	.68250
3.00	.02233	.15241	.35338	.54159	.67820	.76317	.81083	.83565	.84788	
4.00	.02281	.15769	.37051	.57479	.72706	.82439	.88049	.91048	.92563	.93296
5.00	.02292	.15913	.37585	.58624	.74526	.84853	.90908	.94204	.95900	.96735
6.00	.02294	.15950	.37742	.58996	.75165	.85753	.92021	.95472	.97269	.98164
7.00	.02294	.15960	.37786	.59111	.75379	.86073	.92437	.95962	.97812	.98741
8.00	.02295	.15962	.37798	.59146	.75448	.86183	.92587	.96146	.98021	.98967
9.00	.02295	.15962	.37801	.59156	.75470	.86220	.92640	.96213	.98099	.99055
10.00	.02295	.15963	.37802	.59158	.75476	.86232	.92658	.96237	.98128	.99087

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

		1	2	3	4	5	6	7	8	9
OBSERVED EXPECTED		0	1	1	1	2	2	3	3	3
		.04473	.63967	2.68414	6.95148	13.86415	23.19646	33.45749	40.23577	28.82610
		CHI-SQUARE = 6.07990 CELLS USED= 811.E., CELL COUNTS GREATER THAN OR EQUAL TO 51 EXPECTED DISTRIBUTION								
		10.	20.	30.	40.	50.	60.	70.	80.	90.
ANGLE										
CUMULATIVE PROBABILITY		.00030	.00456	.02246	.06880	.16123	.31587	.53892	.80716	1.00000
SECTOR PROBABILITY		.00030	.00426	.01789	.04634	.09243	.15464	.22305	.26824	.19284

Table A16. observed and Expected (Gamma) Cell Counts, VAPB Winter, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lu} * L_u$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |u'| * |u'|$	1	3	0	3	4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	4	6	6	12	3	1	6	0	1	0	0	1	0	0	0	0	0	0	0
	3	0	0	7	6	8	10	7	2	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	3	4	3	5	5	1	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	2	6	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

		$p = .2802 \quad \gamma_1 = 2.6077 \quad \gamma_2 = 4.5529 \quad \eta = .3702$									
		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.30	2.49	4.53	4.58	3.44	2.16	1.21	.62	.30	.14	
2.00	.46	9.22	8.64	9.70	7.39	5.46	3.29	1.81	.93	.46	
3.00	.26	2.69	6.22	7.82	7.11	5.31	3.96	2.04	1.12	.58	
4.00	.11	1.26	3.28	4.57	9.57	3.71	2.60	1.65	.96	.53	
5.00	.04	.51	1.47	2.27	2.47	2.17	1.69	1.11	.69	.40	
6.00	.01	.19	.60	1.01	1.20	1.13	.92	.66	.43	.26	
7.00	.00	.06	.23	.42	.54	.55	.47	.36	.25	.16	
8.00	.00	.02	.08	.17	.83	.25	.23	.18	.13	.09	
9.00	.00	.01	.03	.06	.09	.11	.10	.09	.07	.05	
10.00	.00	.00	.01	.04	.04	.04	.04	.04	.04	.02	

CHI-SQUARE = 9.0092 CELLS USED = 711 E.C. CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00200	.01852	.0467	.07924	.10214	.11653	.12459	.12874	.13076	.13170
2.00	.00503	.04969	.1374	.23271	.30890	.33968	.38965	.40581	.41411	.41810
3.00	.00674	.06931	.1986	.34592	.46953	.55569	.60871	.63851	.65429	.66215
4.00	.00745	.07840	.2295	.40731	.56139	.67225	.74264	.78341	.80561	.81699
5.00	.00770	.08202	.2429	.43584	.60639	.73173	.81304	.86121	.88795	.90197
6.00	.00778	.08334	.2482	.44789	.62644	.75934	.84676	.89934	.92994	.94471
7.00	.00781	.08379	.2502	.45266	.63481	.77135	.86191	.91681	.94813	.96496
8.00	.00781	.08394	.2501	.45446	.6381	.77632	.86839	.92451	.95675	.97415
9.00	.00782	.08398	.2511	.45511	.6393	.77830	.87106	.92781	.96042	.97817
10.00	.00783	.08400	.2511	.45534	.6396	.77906	.87213	.92911	.96196	.97969

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

		1	2	3	4	5	6	7	8	9
OBSERVED EXPECTED		.06302	.12979	.05563	.10206	.28081	.02032	.44825	.31848	.115283
		CHI-SQUARE = 9.47236	CELLS USED = 611 E.C. CELL COUNTS GREATER THAN OR EQUAL TO 5)	EXPECTED DISTRIBUTION						
ANNUAL PROBABILITY		.00042	.00095	.00032	.00018	.00005	.00005	.00034	.00065	.00000
SECTOR PROBABILITY		.00042	.00073	.00237	.00988	.04187	.20680	.24548	.21231	.07435

Table A17. Observed and Expected (Gamma) Cell Counts, VAPB Winter, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		B _{Lv} * L _v																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B | v' | * | v' |	1	3	2	2	1	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	3	6	6	9	6	3	4	0	3	0	0	0	0	0	0	0	0	0	0
	3	0	0	6	6	6	4	4	2	2	1	1	1	0	0	0	0	0	0	0	0
	4	0	0	1	5	4	4	3	1	2	1	1	0	0	0	0	0	0	0	0	0
	5	0	0	2	1	6	3	3	1	0	1	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

		$\rho = .2898 \quad \gamma_1 = 2.5709 \quad \gamma_2 = 4.7895 \quad \eta = .3956$									
		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.22	2.15	4.38	4.77	3.80	2.50	1.45	.78	.39	.19	
2.00	.31	3.43	7.89	9.61	8.42	6.05	3.80	2.17	1.15	.58	
3.00	.16	2.06	5.41	1.41	7.21	5.68	3.87	2.37	1.35	.72	
4.00	.06	.92	e.72	4.17	4.40	3.05	2.04	1.07	1.13	.64	
5.00	.02	.35	1.17	1.99	2.34	2.19	1.74	1.23	.79	.47	
6.00	.01	.12	.46	.86	1.10	1.11	.95	.71	.49	.31	
7.00	.00	.04	.17	.34	.40	.52	.47	.38	.27	.18	
8.00	.00	.01	.06	.13	.20	.23	.22	.19	.14	.10	
9.00	.00	.00	.02	.05	.08	.10	.10	.09	.07	.05	
10.00	.00	.00	.01	.02	.03	.04	.04	.04	.03	.03	

CHI-SQUARE = 1.81398 CELLS USED = 711 E., CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00147	.01580	.04498	.07682	.10212	.11878	.12848	.13365	.13625	.13750	
2.00	.00354	.04077	.12253	.21843	.29989	.35685	.39185	.41147	.42174	.42685	
3.00	.00463	.05561	.17342	.31874	.44829	.54310	.60389	.63933	.65858	.66847	
4.00	.00505	.06214	.19807	.37118	.53057	.65103	.73072	.77861	.80538	.81953	
5.00	.00519	.06462	.20834	.39470	.56972	.70477	.79604	.85210	.88412	.90140	
6.00	.00524	.06547	.21223	.40429	.58665	.72911	.82671	.88752	.92278	.94211	
7.00	.00525	.06575	.21361	.40796	.59351	.73944	.84020	.90354	.94063	.96118	
8.00	.00525	.06584	.21408	.40929	.59615	.74360	.84585	.91045	.94851	.96973	
9.00	.00526	.06586	.21423	.40976	.59712	.74522	.84813	.91332	.95186	.97343	
10.00	.00526	.06587	.21428	.40992	.59747	.74583	.84901	.91448	.95324	.97498	

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

		1	2	3	4	5	6	7	8	9
OBSERVED EXPECTED		0	0	0	0	0	0	0	0	0
		.03281	.72853	3.83240	9.89086	19.41426	30.35837	38.21277	34.83982	12.89018
CHI-SQUARE = 3.19877 CELLS USED = 61 I.E., CELL COUNTS GREATER THAN OR EQUAL TO 51										
EXP. DISTRIBUTION										
ANGLE		10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY		.00022	.00508	.02929	.09523	.22466	.42705	.68180	.91407	1.00000
SECTOR PROBABILITY		.00022	.00486	.02422	.06594	.12943	.20239	.25475	.23227	.08593

Table A18. Observed and Expected (Gamma) Cell Counts, VAFB Transition, Jimsphere, 12 km, Wavelength Range. 90-420 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		B _{Lu} * Lu																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B | u' | * | u' |	1	1	2	4	4	2	3	0	1	1	1	0	0	0	0	0	0	0	0	0	0
	2	0	1	7	4	9	5	10	6	1	1	0	1	0	0	0	0	0	0	0	0
	3	0	0	4	0	1	4	10	6	0	2	2	1	0	0	0	0	0	0	0	0
	4	0	0	2	1	5	4	2	3	2	3	1	0	1	0	0	0	0	0	0	0
	5	0	0	0	0	0	4	4	1	1	3	2	1	0	0	0	0	0	0	0	0
	6	0	0	0	0	2	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .2768$

$\gamma_1 = 2.6824$

$\gamma_2 = 5.9186$

$n = .4111$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.03	.61	2.11	3.38	3.62	3.05	2.18	1.39	.82	.45
2.00	.04	1.02	3.91	6.91	8.09	7.38	5.65	3.85	2.39	1.38
3.00	.02	.61	2.63	5.18	6.68	6.63	5.50	4.01	2.65	1.62
4.00	.01	.26	1.28	2.79	3.95	4.26	3.81	2.97	2.09	1.35
5.00	.00	.10	.53	1.27	1.97	2.50	2.21	1.84	1.37	.94
6.00	.00	.03	.20	.52	.88	1.11	1.14	1.01	.80	.58
7.00	.00	.01	.07	.20	.36	.49	.54	.51	.43	.32
8.00	.00	.00	.02	.07	.14	.21	.24	.24	.21	.17
9.00	.00	.00	.01	.02	.05	.08	.10	.11	.10	.08
10.00	.00	.00	.00	.01	.03	.03	.04	.05	.05	.04

CHI-SQUARE = 7.88411 CELLS USED = 411 E. CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00019	.00426	.01833	.04088	.06504	.08536	.09990	.10920	.11467	.11768
2.00	.00046	.01131	.05143	.12002	.19812	.26752	.31977	.35471	.37611	.38834
3.00	.00061	.01550	.07313	.17624	.29888	.41246	.50137	.56303	.60209	.62514
4.00	.00067	.01731	.08345	.20516	.35415	.49615	.61047	.69196	.74495	.77702
5.00	.00069	.01798	.08762	.21782	.37992	.53725	.66629	.76004	.82217	.86049
6.00	.00069	.01820	.08916	.22283	.39079	.55550	.69214	.79262	.86008	.90224
7.00	.00069	.01827	.08969	.22468	.39507	.56306	.70330	.80719	.87748	.92180
8.00	.00069	.01829	.08986	.22533	.39566	.56602	.70788	.81337	.88508	.93053
9.00	.00069	.01830	.08991	.22555	.39572	.56714	.70968	.81589	.88827	.93428
10.00	.00069	.01830	.08993	.22562	.39573	.56755	.71036	.81688	.88957	.93584

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

		1	2	3	4	5	6	7	8	9
OBSERVED EXPECTED		0	0	2	7	9	33	30	56	13
		.00335	.16581	1.36638	5.33541	13.83897	27.13013	41.17909	43.56314	17.41773
		CHI-SQUARE = 11.18728 CELLS USED = 6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5) EXPECTED DISTRIBUTION								
		10.	20.	30.	40.	50.	60.	70.	80.	90.
ANGLE		.00002	.00113	.01024	.04581	.13807	.31893	.59346	.88388	1.00000
CUMULATIVE PROBABILITY		.00002	.00111	.00911	.03557	.09226	.18087	.27453	.29042	.11612
SECTOR PROBABILITY										

Table A19. Observed and Expected (Gamma) Cell Counts. VAFB Transition, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lv} * L_v$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |v'| * |v'|$	1	5	15	7	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	12	11	11	7	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0
	3	1	5	9	9	9	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	2	2	2	3	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	1	1	1	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

		$\rho = .3755 \quad \gamma_1 = 2.2247 \quad \gamma_2 = 3.4086 \quad \eta = .4648$									
		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	2.72	8.99	8.72	5.53	2.88	1.32	.57	.23	.09	.04	
2.00	2.62	10.88	13.09	9.93	5.95	3.10	1.47	.65	.28	.11	
3.00	1.06	5.57	8.31	7.55	5.26	3.11	1.64	.60	.36	.16	
4.00	.33	2.19	3.96	4.24	3.40	2.26	1.32	.70	.35	.16	
5.00	.09	.75	1.62	2.01	1.83	1.37	.88	.51	.28	.14	
6.00	.02	.23	.60	.85	.67	.72	.51	.33	.19	.10	
7.00	.01	.07	.20	.33	.38	.35	.27	.19	.12	.07	
8.00	.00	.02	.07	.12	.15	.16	.13	.10	.07	.04	
9.00	.00	.01	.02	.04	.06	.07	.06	.05	.03	.02	
10.00	.00	.00	.01	.01	.02	.03	.03	.02	.02	.01	

CHI-SQUARE = 8.18239 CELLS USED = 10 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01814	.07807	.13617	.17303	.19212	.20093	.20472	.20628	.20690	.20715
2.00	.03564	.16811	.31348	.41658	.47534	.50480	.51838	.52426	.52672	.52771
3.00	.04271	.21231	.41311	.56656	.66044	.71061	.73509	.74629	.75118	.75323
4.00	.04495	.22911	.45634	.63808	.75463	.81988	.85320	.86910	.87631	.87945
5.00	.04557	.23472	.47273	.66788	.79664	.87101	.91021	.92953	.93857	.94264
6.00	.04573	.23644	.47843	.67925	.81384	.89303	.93566	.95716	.96746	.97220
7.00	.04577	.23694	.48029	.68332	.82045	.90196	.94640	.96914	.98022	.98540
8.00	.04578	.23708	.48087	.68470	.82286	.90541	.95073	.97412	.98563	.99109
9.00	.04578	.23711	.48104	.68515	.82371	.90670	.95241	.97612	.98786	.99347
10.00	.04578	.23712	.48109	.68530	.82400	.90716	.95304	.97690	.98875	.99444

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

		1	2	3	4	5	6	7	8	9
OBSERVED EXPECTED		0	1	8	15	19	33	44	28	2
		.27089	2.56744	7.94353	15.77473	24.28909	30.89948	32.50697	25.98889	9.78140
CHI-SQUARE = 5.95562 CELLS USED = 6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)										
EXPECTED DISTRIBUTION										
ANGLE		10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY		.00180	.01892	.07188	.17704	.33897	.54497	.76168	.93478	1.00000
SECTOR PROBABILITY		.00180	.01712	.05296	.10516	.16193	.20600	.21671	.17311	.06521

Table A20. Observed and Expected (Gamma) Cell Counts, VAB Transition, Jimsphere, 12 km, Wavelength Range, 420-2470 m, Non-dimensionalized $|u'|$ and L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * L_u$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B|u'| \cdot |u'|$	1	5	8	3	6	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0
	2	0	5	10	8	7	5	6	3	1	0	0	1	0	0	0	0	0	0	0
	3	0	0	6	6	4	8	3	0	0	1	1	0	0	0	0	0	0	0	0
	4	0	0	0	8	4	7	1	0	1	0	0	0	0	0	0	0	0	0	0
	5	0	0	1	2	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .2119$

$\gamma_1 = 2.4196$

$\gamma_2 = 4.3057$

$n = .2826$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.45	3.30	5.50	5.62	4.19	2.65	1.50	.78	.39	.18
2.00	.65	5.12	9.54	10.18	8.14	5.46	3.29	1.81	.84	.46
3.00	.38	3.25	6.60	7.83	6.57	4.73	3.01	1.76	.96	.50
4.00	.17	1.57	3.48	4.33	4.00	3.07	2.08	1.28	.73	.40
5.00	.07	.67	1.80	2.14	2.11	1.72	1.23	.80	.48	.27
6.00	.02	.22	.68	.87	1.02	.88	.66	.45	.28	.17
7.00	.01	.10	.27	.42	.46	.42	.33	.24	.16	.10
8.00	.00	.04	.10	.11	.20	.19	.16	.12	.08	.05
9.00	.00	.01	.05	.07	.08	.08	.07	.06	.04	.03
10.00	.00	.00	.01	.03	.03	.04	.03	.03	.02	.01

CHI-SQUARE = 1.12193 CELLS USED = 8 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00302	.02501	.06289	.10033	.12827	.14592	.15590	.16111	.16370	.16492
2.00	.00736	.06352	.16511	.27041	.35265	.40684	.43872	.45603	.46487	.46919
3.00	.00989	.08771	.23333	.38948	.51551	.60122	.65320	.68224	.69750	.70514
4.00	.01102	.09932	.26813	.45317	.60589	.71208	.77790	.81547	.83562	.84592
5.00	.01147	.10422	.28309	.48302	.64983	.76750	.84152	.88440	.90775	.91986
6.00	.01183	.10614	.29012	.49593	.66955	.79308	.87150	.91738	.94262	.95584
7.00	.01188	.10644	.29264	.50122	.67793	.80425	.88490	.93236	.95862	.97249
8.00	.01170	.10710	.29358	.50330	.68134	.80896	.89065	.93889	.96570	.97990
9.00	.01171	.10718	.29393	.50410	.68269	.81087	.89309	.94166	.96873	.98311
10.00	.01171	.10721	.29403	.50439	.68322	.81162	.89402	.94281	.97001	.98447

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	3	9	24	35	32	38	9
EXPECTED	.12377	1.64281	5.73031	12.15244	20.15559	28.93286	34.73003	32.96639	13.96580
CHI-SQUARE =	5.78571								
CELLS USED =	8								
(I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00083	.01178	.04998	.13100	.26537	.45559	.68712	.90689	1.00000
SECTOR PROBABILITY	.00083	.01095	.03820	.08102	.13437	.19022	.23153	.21978	.09311

Table A21. observed and Expected (Gamma) Cell Counts, VAFB Transition, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Square8

Observed Cell Count

sample Size = 150

		$B_{Lv} * Lv$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |v'| * |v'|$	1	4	13	5	4	1	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	2	7	12	3	5	2	2	0	1	0	0	0	0	0	0	0	0	0	0
	3	0	11	12	5	5	2	2	0	1	0	0	1	0	0	0	0	0	0	0	0
	4	0	0	6	5	5	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	5	0	0	7	3	4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$P = .2063$

$\gamma_1 = 2.4816$

$\gamma_2 = 3.3918$

$\eta = .2412$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	1.56	5.70	6.25	4.49	2.62	1.35	.65	.29	.13	.05
2.00	2.52	9.90	11.77	9.14	5.71	3.17	1.61	.77	.35	.15
3.00	1.62	6.91	8.96	7.55	5.11	3.02	1.63	.83	.40	.18
4.00	.79	3.65	5.14	4.67	3.39	2.13	1.22	.65	.33	.16
5.00	.34	1.68	2.56	2.50	1.93	1.29	.78	.44	.23	.12
6.00	.13	.71	1.17	1.22	1.00	.71	.45	.26	.15	.08
7.00	.05	.29	.50	.56	.49	.36	.24	.15	.09	.05
8.00	.02	.11	.21	.25	.22	.17	.12	.08	.05	.03
9.00	.01	.04	.08	.10	.10	.08	.06	.04	.02	.01
10.00	.00	.02	.03	.04	.04	.03	.02	.01	.01	.00

CHI-SQUARE= 16.89024 CELLS USED= 811.E., CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.0104	.04410	.09003	.11000	.13747	.14601	.15002	.15777	.15761	.15740
2.00	.02721	.13110	.25126	.34212	.39740	.42803	.44306	.45011	.45558	.45946
3.00	.03800	.18004	.30780	.40003	.45001	.47012	.47503	.48759	.49441	.49901
4.00	.04325	.21783	.43172	.60406	.71641	.78015	.81501	.83192	.84045	.84967
5.00	.04549	.23108	.46226	.65125	.77848	.84902	.88888	.90871	.91878	.92773
6.00	.04658	.23672	.47571	.67204	.80474	.88500	.92485	.94444	.95498	.96195
7.00	.04670	.23836	.48131	.68210	.81733	.89758	.94144	.96402	.97512	.98040
8.00	.04682	.23892	.48358	.68608	.82270	.90418	.94680	.97189	.98331	.98776
9.00	.04688	.24014	.48443	.68763	.82403	.90600	.94896	.97532	.98690	.99045
10.00	.04688	.24025	.48476	.68824	.82583	.90804	.95329	.97677	.98843	.99403

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	8	34	17	27	31	22	10
EXPECTED	.02250	5.43818	12.17936	18.90127	24.57522	28.35350	28.72930	22.07175	8.13043
CHI-SQUARE= 16.53787 CELLS USED= 711.E., CELL COUNTS GREATER THAN OR EQUAL TO 51									
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00540	.04172	.12292	.24893	.41277	.60179	.79332	.94580	1.00000
SECTOR PROBABILITY	.00540	.03624	.08120	.12601	.16383	.18902	.19153	.15240	.05420

Table A22. Observed and Expected (Gamma) Cell Counts, VAHB Summer, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		B _{Lu} • Lu																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B | u' | * | u' |	1	3	1	6	5	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	5	8	10	14	4	4	1	1	0	0	0	0	0	0	0	0	0	0	0
	3	0	2	1	3	1	0	9	6	3	3	1	2	1	0	0	0	0	0	0	0
	4	0	0	1	2	2	5	3	2	3	1	3	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	2	4	3	3	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	1	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

		$\rho = .3090 \quad \gamma_1 = 2.5139 \quad \gamma_2 = 5.0005 \quad \eta = .4358$									
		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.17	1.97	4.37	5.07	4.21	2.87	1.72	.94	.48	.24	
2.00	.22	2.85	7.26	9.52	8.81	6.59	4.28	2.52	1.37	.70	
3.00	.10	1.56	4.64	6.93	7.20	5.96	4.23	2.68	1.56	.85	
4.00	.04	.64	2.18	3.69	4.28	3.90	3.01	2.06	1.29	.75	
5.00	.01	.23	.88	1.67	2.15	2.14	1.80	1.32	.88	.54	
6.00	.00	.07	.32	.68	.96	1.05	.95	.75	.53	.35	
7.00	.00	.02	.11	.26	.40	.47	.46	.39	.30	.20	
8.00	.00	.01	.04	.09	.16	.20	.21	.19	.15	.11	
9.00	.00	.00	.01	.03	.06	.08	.09	.09	.07	.06	
10.00	.00	.00	.00	.01	.02	.03	.04	.04	.03	.03	

CHI-SQUARE = 5.80508 CELLS USED = 6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00117	.01428	.04344	.07722	.10529	.12444	.13593	.14222	.14545	.14703
2.00	.00263	.03471	.11227	.20950	.29628	.33939	.39942	.42248	.43485	.44112
3.00	.00331	.04583	.15429	.29774	.43252	.53535	.60356	.64450	.66728	.67925
4.00	.00356	.05033	.17333	.34141	.50472	.63355	.72185	.77653	.80789	.82484
5.00	.00363	.05191	.18075	.35998	.53759	.68071	.78098	.84448	.88172	.90229
6.00	.00365	.05241	.18339	.36715	.55120	.70131	.80792	.87643	.91724	.94014
7.00	.00365	.05256	.18427	.36975	.55646	.70972	.81941	.89052	.93330	.95757
8.00	.00366	.05261	.18455	.37054	.55839	.71298	.82407	.89645	.94024	.96524
9.00	.00366	.05262	.18463	.37074	.55907	.71420	.82588	.89884	.94312	.96851
10.00	.00366	.05262	.18466	.37103	.55930	.71464	.82657	.89977	.94428	.96985

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	3	5	17	28	48	44	5
EXPECTED	.01951	.43428	2.56805	7.98330	17.38792	29.41591	39.41712	37.90742	14.88878
CHI-SQUARE = 10.60759 CELLS USED = 6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00010	.00300	.02012	.07335	.18913	.38524	.64802	.90074	1.00000
SECTOR PROBABILITY	.00010	.00290	.01713	.05322	.11579	.19611	.26278	.25272	.09926

Table A23. Observed and Expected (Gamma) Cell Counts, VAFB Summer, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lv} * L_v$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |v'| * |v'|$	1	0	12	5	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	2	11	7	5	2	3	3	0	0	0	1	0	0	0	0	0	0	0	0	0
	3	0	2	10	8	6	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	2	8	6	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .3368$

$\gamma_1 = 2.4416$

$\gamma_2 = 3.3521$

$\eta = .3947$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	2.21	7.07	6.77	4.27	2.20	1.01	.43	.18	.07	.03
2.00	2.89	10.96	12.44	9.12	5.35	2.57	1.29	.57	.24	.10
3.00	1.48	6.74	9.09	7.74	5.17	2.97	1.54	.74	.34	.15
4.00	.58	3.10	4.89	4.77	3.59	2.29	1.30	.68	.33	.15
5.00	.20	1.23	2.24	2.98	2.07	1.46	.90	.51	.27	.13
6.00	.06	.45	.93	1.15	1.06	.82	.55	.33	.19	.10
7.00	.02	.15	.36	.49	.50	.42	.30	.20	.12	.07
8.00	.01	.05	.13	.20	.22	.20	.15	.11	.07	.04
9.00	.00	.02	.05	.08	.09	.09	.07	.05	.04	.02
10.00	.00	.00	.02	.03	.04	.04	.03	.03	.02	.01

CHI-SQUARE = 9.32636 CELLS USED = 911.E..CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01471	.06183	.10696	.13544	.15013	.15688	.15975	.16092	.16138	.16156
2.00	.03399	.15421	.28229	.37154	.42189	.44693	.45838	.46333	.46538	.46620
3.00	.04388	.20901	.39760	.53851	.62331	.66814	.68985	.69972	.70400	.70575
4.00	.04772	.23349	.45477	.62741	.73613	.79620	.82657	.84096	.84745	.85027
5.00	.04902	.24298	.47921	.66835	.79090	.86068	.89706	.91485	.92312	.92682
6.00	.04943	.24636	.48677	.68557	.81521	.89043	.93047	.95047	.95999	.96435
7.00	.04955	.24748	.49229	.69236	.82534	.90334	.94539	.96670	.97701	.98181
8.00	.04958	.24785	.49351	.69491	.82935	.90868	.95175	.97379	.98455	.98961
9.00	.04959	.24796	.49393	.69583	.83088	.91080	.95438	.97677	.98778	.99300
10.00	.04960	.24799	.49406	.69616	.83145	.91162	.95542	.97800	.98913	.99444

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	12	18	27	34	30	29	1
EXPECTED	.51017	4.08583	10.85150	18.95504	26.28489	30.68858	29.88631	21.78320	6.99449
CHI-SQUARE = 3.35038 CELLS USED = 611.E..CELL COUNTS GREATER THAN OR EQUAL TO 51									
EXPECTED DISTRIBUTION									
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00340	.03064	.10298	.22935	.40458	.60917	.80942	.95384	1.00000
SECTOR PROBABILITY	.00340	.02724	.07234	.12637	.17523	.20459	.19924	.14522	.04616

Table A24. Observed and Expected (Gamma) Cell Counts, VAB Summer, Jimsphere, 12 km, wavelength Range, 420-2470 m, Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} \cdot L_u$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	8	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	11	11	9	1	0	6	1	1	0	0	0	0	0	0	0	0	0	0	0
3	0	1	9	9	7	3	0	1	2	0	0	0	0	0	0	0	0	0	0	0
4	0	1	2	9	5	3	2	2	0	0	0	1	0	0	0	0	0	0	0	0
5	0	0	1	2	4	2	~	1	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
7	0	0	1	4	1	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	7	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

$\rho = .3578$

$\gamma_1 = 2.6448$

$\gamma_2 = 3.8826$

$\eta = .4335$

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	93	4 39	5 34	3 95	2 29	1 15	53	23	10	.04
2.00	1 37	7 66	11 08	9 54	6 30	3 54	1 79	84	37	.16
3.00	71	4 85	8 41	8 47	6 41	4 05	2 27	1 16	56	.25
4.00	27	2 21	4 54	5 28	4 53	3 20	1 97	1 10	57	.28
5.00	09	86	2 05	2 72	2 62	2 05	1 38	84	47	.24
6.00	03	30	82	1 24	1 33	1 14	84	55	33	.18
7.00	01	10	31	52	61	58	46	33	21	.12
8.00	00	03	11	20	26	27	23	18	12	.08
9.00	00	01	04	07	11	12	11	09	07	.04
10.00	00	00	01	03	04	05	05	04	03	.02

CHI-SQUARE. 6 41015 CELLS USED= 8 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00622	.03552	.07113	.09746	.11271	.12040	.12393	.12547	.12611	.12637
2.00	.01532	.09567	.20512	.29503	.35228	.38358	.39907	.40621	.40934	.41067
3.00	.02009	.13276	.29827	.44467	.54462	.60292	.63352	.64841	.65526	.65827
4.00	.02191	.14934	.34510	.52673	.65686	.73646	.78019	.80242	.81307	.81795
5.00	.02250	.15565	.36506	.56484	.71243	.80569	.85866	.88649	.90027	.90677
6.00	.02268	.15782	.37273	.58077	.73724	.83813	.89672	.92824	.94423	.95196
7.00	.02273	.15852	.37547	.58696	.74752	.85226	.91394	.94764	.96502	.97359
8.00	.02274	.15873	.37640	.58924	.75155	.85809	.92132	.95620	.97440	.98348
9.00	.02275	.15879	.37670	.59003	.75305	.86039	.92436	.95983	.97847	.98784
10.00	.02275	.15881	.37679	.59030	.75360	.86126	.92556	.96132	.98018	.98970

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	8	13	31	36	31	26	5
EXPECTED	.18233	2.27353	7.98986	16.80820	26.36406	33.12780	33.13930	23.46334	6.65151
CHI-SQUARE=	2.74946		CELLS USED=	7 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)					
				EXPECTED DISTRIBUTION					
ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00122	.01637	.06964	.18169	.35745	.57831	.75923	.95566	1.00000
SECTOR PROBABILITY	.00122	.01516	.05327	.11205	.17576	.22085	.22093	.15642	.04434

Table A25. Observed and Expected (Gamma) Cell Counts, VAFB Summer, Jimsphere, 12 km, Wavelength Range, 420-2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

		$B_{Lv} * L_v$																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$B |v'| * |v'|$	1	4	9	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	3	8	2	5	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	4	13	6	10	5	4	1	0	1	0	0	0	0	0	0	0	0	0	0
	4	0	1	6	4	5	4	3	2	0	2	0	1	0	0	0	0	0	0	0	0
	5	0	0	2	4	3	3	1	3	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	5	2	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

	$\rho = .3390$		$\gamma_1 = 2.9615$		$\gamma_2 = 4.1560$		$\eta = .4016$			
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.43	2.49	3.47	2.81	1.75	.93	.45	.20	.09	.04
2.00	.86	5.71	9.19	8.51	5.95	3.50	1.84	.89	.41	.18
3.00	.55	4.32	8.11	8.62	6.80	4.46	2.58	1.36	.67	.31
4.00	.25	2.25	4.88	5.90	5.21	3.78	2.39	1.37	.73	.36
5.00	.09	.97	2.41	3.21	3.22	2.56	1.76	1.09	.62	.33
6.00	.03	.37	1.05	1.60	1.73	1.50	1.12	.74	.45	.26
7.00	.01	.13	.42	.71	.84	.79	.64	.45	.29	.18
8.00	.00	.04	.16	.29	.38	.39	.33	.25	.17	.11
9.00	.00	.01	.06	.12	.16	.18	.16	.13	.10	.06
10.00	.00	.00	.02	.04	.07	.08	.08	.07	.05	.04
CHI-SQUARE		5.56650		CELLS USED =		6 (I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)				

CHI-SQUARE= 5.56650 CELLS USED= 6(I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00288	.01949	.04259	.06135	.07301	.07921	.08219	.08353	.08410	.08434
2.00	.00860	.06331	.14765	.22315	.27446	.30401	.31928	.32658	.32989	.33132
3.00	.01230	.09580	.23420	.36718	.46383	.52313	.55560	.57198	.57976	.58329
4.00	.01395	.11245	.28337	.45566	.58704	.67153	.71993	.74544	.75806	.76400
5.00	.01457	.11955	.30652	.50067	.65349	.75505	.81521	.84799	.86474	.87288
6.00	.01478	.12225	.31623	.52103	.68538	.79695	.86457	.90231	.92207	.93192
7.00	.01484	.12320	.31999	.52953	.69949	.81635	.88823	.92898	.95071	.96173
8.00	.01486	.12352	.32136	.53286	.70536	.82481	.89891	.94136	.96425	.97601
9.00	.01487	.12362	.32184	.53411	.70768	.82832	.90352	.94685	.97038	.98257
10.00	.01487	.12365	.32200	.53456	.70857	.82972	.90543	.94920	.97306	.98549

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees

Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	5	24	26	35	33	26	8
EXPECTED	.16875	2.36625	8.62914	18.19024	28.08763	34.24971	32.55081	20.91976	4.63765
CHI-SQUARE= 4.79338 CELLS USED= 6(I.E., CELL COUNTS GREATER THAN OR EQUAL TO 5)									
EXPECTED DISTRIBUTION									
ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00112	.01690	.07443	.19570	.38295	.61128	.82828	.96775	1.00000
SECTOR PROBABILITY	.00112	.01578	.05753	.12127	.18725	.22833	.21701	.13947	.03225